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**Design and Procurement Bases for
Coast Guard Aircraft Simulators**

by

**Paul W. Caro, Eugene R. Hall, and
Cmdr. Gilbert E. Brown, Jr.**

December 1969

Prepared for:

**The United States
Coast Guard**

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HumRRO Division No. 6 (Aviation)
Fort Rucker, Alabama
HUMAN RESOURCES RESEARCH ORGANIZATION

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The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University, Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation.

The findings in this report have not been approved by the Commandant of the Coast Guard and do not reflect official Coast Guard policy, unless so designated by other authorized documents.

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FOREWORD

In reaction to increasingly complex equipment and increasing operating costs in the conduct of training for operation of both rotary-wing and fixed-wing aircraft, the U.S. Coast Guard undertook exploration of the potential usefulness of flight training devices in its aviator training program. In support of that exploration, the Human Resources Research Organization conducted a study of Coast Guard aviator training requirements. The study was conducted during the period February through November, 1969 and a consulting report was prepared. Aviator training requirements identified during that study are described in HumRRO Technical Report 69-102, *A Study of U.S. Coast Guard Aviator Training Requirements*. The present technical report, which was prepared during the same time period, builds upon the training requirements information contained in that report.

Characteristics of flight training equipment designed to provide Coast Guard aviator training are described in a Qualitative Materiel Requirement (QMR) which constitutes Appendix A to this report. The QMR describes training devices which, when used in a comprehensive training program involving academic, synthetic, and aircraft training, may be expected to contribute significantly to the effectiveness and efficiency of Coast Guard aviator training. Familiarity with the contents of *A Study of U.S. Coast Guard Aviator Training Requirements*, particularly with the requirements which can be met through synthetic flight training, will contribute to an understanding of the equipment characteristics stated in the QMR.

This study was performed by HumRRO Division No. 6 (Aviation) at Fort Rucker, Alabama. Dr. Wallace W. Prophet is the Director. Dr. Paul W. Caro was the Principal Investigator for the Coast Guard studies, and Commander Gilbert E. Brown, Jr., was the Coast Guard Technical Monitor for the contract.

All cost estimates associated with the procurement, operation, and maintenance of the aircraft simulators described herein were developed by Simulation Engineering Corporation, Fairfax, Virginia. The estimates were developed during the course of consulting services to HumRRO provided by that firm. Other cost data were provided by the Coast Guard, as were the projections of aircraft and personnel strength included in the report.

This HumRRO study for the U.S. Coast Guard was performed under Contract DOT-CG-92556-A.

Meredith P. Crawford
President
Human Resources Research Organization

SUMMARY AND CONCLUSIONS

STATEMENT OF THE PROBLEM

Recent years have seen an accelerating growth in the capabilities and complexities of modern helicopters and airplanes. These changes have resulted in corresponding increases in the complexity of training requirements. During this period, aircraft have emerged as principal vehicles for Coast Guard search and rescue operations. While Coast Guard operational mission requirements and, hence, flight training requirements have much in common with those of the other services, they have unique aspects that must be provided for adequately in Coast Guard flight training and flight training equipment.

The increases in aircraft complexity have brought with them increases in operating costs. Therefore, it becomes even more important to examine means for reducing flight training costs while maintaining the Coast Guard's high standards of operational readiness. For this reason, exploration of the potential role of flight training devices in Coast Guard aviator training programs was initiated.

BACKGROUND AND APPROACH

The objective of the study undertaken by HumRRO was to analyze Coast Guard aviator training requirements in order to determine functional requirements for flight training devices or simulators necessary to support the Coast Guard flight training program. The study involved four steps: (1) analysis of operational missions and derivation of training requirements; (2) analysis of trainee input factors; (3) definition of the characteristics of required synthetic training equipment; and (4) development of plans for the funding and procurement of the required synthetic training equipment. Steps 1 and 2 have been reported,¹ while Steps 3 and 4 are covered in this report.

Familiarity with the training requirements identified in the preceding report, particularly those requirements associated with synthetic flight training, will contribute to an understanding of the equipment requirements stated herein. The primary justification for the Coast Guard to obtain flight training devices is that they will facilitate meeting those training requirements. The present report discusses the magnitude of the synthetic flight training requirement and the cost-effectiveness benefits to be realized from use of such equipment.

Characteristics of required synthetic training equipment have been stated in the form of a Qualitative Materiel Requirement (QMR) for a Variable Cockpit Training System (VCTS). The QMR constitutes Appendix A of this report.

FINDINGS

(1) The primary requirement for Coast Guard aviator training devices is to provide training in mission-critical skills related to whole mission accomplishment and to prepare the aviator to deal with unexpected events under stressful conditions. This training can best be provided in relatively sophisticated aircraft simulators.

(2) For the mid-1970s, there is an annual requirement for approximately 3,165 aircraft simulator cockpit hours for projected HH52A, HH3F, HU16E, and HC130B transition and qualification training of Coast Guard aviators.

¹ Eugene R. Hall, Paul W. Caro, Jr., Oran B. Jolley, and Cmdr. Gilbert E. Brown, Jr. *A Study of U.S. Coast Guard Aviator Training Requirements*, HumRRO Technical Report 69-102, December 1969.

(3) For the same time frame, there is an annual requirement for approximately 7,663 aircraft simulator cockpit hours for projected training and evaluation of Coast Guard aviators assigned to operational units.

(4) Costs saved through use of a rotary-wing configuration of the VCTS, that is, HH52A and HH3F simulators, can offset acquisition costs in as little as 1.1 years.

(5) Costs saved through use of a fixed-wing configuration of the VCTS, that is, HU16E and HC130B simulators, can offset acquisition costs in as little as 1.7 years.

(6) Annual aviator training cost savings that can be realized as a consequence of VCTS utilization will be approximately \$3,650,000.

(7) The following aircraft, presently required exclusively to support aviator training, can be freed for other uses through substituting VCTS training for training in aircraft: three HH3Fs, two HH52As, one HU16E, and one HC130B.

(8) Procurement of the VCTS will require approximately \$4,560,000 during Fiscal Years 1971 and 1972.

(9) The VCTS can become operational for training in stages. The first part of the system can be in operation during the fourth quarter of FY 1972. The final part of the system can be in operation during the fourth quarter of FY 1973.

CONCLUSION

The functional design characteristics described in the QMR for the VCTS are responsive to Coast Guard training requirements and can contribute to the cost effectiveness of aviator training.

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**Design and Procurement Bases for
Coast Guard Aircraft Simulators**

INTRODUCTION

A training device is a piece of non-operational equipment with which training is undertaken, the objective of that training being the enhancement of subsequent performance in operational equipment. Typically, a flight training device is thought of as a "link trainer", or some other device in which aircraft flight—or an aspect of aircraft flight—may be simulated. In fact, a training device may be anything from a line drawing used to teach engine run-up procedures to an airplane simulator in which all, or almost all, skills associated with operational mission performance may be developed. In some of the more "hi-fi" airplane simulators, critical skills not safe to practice in operational aircraft at all may be developed to high proficiency levels.

From the Coast Guard search and rescue (SAR) mission descriptions and related training requirements developed during the present study¹ skills have been identified which reasonably may be developed in training devices ranging in design complexity from the simplest to the most complex. There are procedural skills which can be developed in very simple training devices, such as the learning of HH3F engine starting procedures in trainers made of paper; there are multi-dimensional skills which can be developed in somewhat more complex devices, such as the learning of instrument navigation in an instrument flight trainer; and there are skills involving the time sharing of procedural and psychomotor elements critical to safety of flight which can be developed only in highly sophisticated mission simulators, such as the learning in a flight simulator of timely responses to various system malfunctions during instrument flight in adverse weather.

Except for instances of aviators transitioning to a new aircraft, where relatively simple procedural and psychomotor skills are being developed, the preponderance of the Coast Guard's aviator training requirement involves refinement of already relatively highly developed skills. These skills largely are aircraft-specific and mission-oriented. They involve operation of complex aircraft under highly stressful and often adverse conditions. Simultaneous qualification in two aircraft is common. The relatively small number of aviators and aircraft involved in Coast Guard aviation and the publicity which often accompanies SAR operations make optimum aviator performance much more critical than is the case in other services. In fact, the skill demands placed upon Coast Guard aviators are more akin to those placed upon commercial carrier pilots than upon other military aviators.

The nature of the Coast Guard aviator training requirement is such that relatively little emphasis can be placed upon low fidelity part-task trainers. The critical skills are those which relate to whole mission accomplishment and preparation of the aviator to deal—almost in routine fashion—with the unexpected events which could jeopardize mission accomplishment. In other words, the primary function of devices required for Coast Guard aviator training is to provide training in mission-critical skills. Secondary functions are to provide training associated with transitioning to new aircraft or operating aircraft under routine conditions.

Flight training devices of the type which will meet the primary training function required for the Coast Guard are called by various names: operational flight trainers, mission simulators, or simply aircraft simulators. The chief characteristics of such devices is that they simulate to a high level of fidelity a specific make and model aircraft and the

¹ Eugene R. Hall, Paul W. Caro, Jr., Oran B. Jolley, and Cmdr. Gilbert E. Brown, Jr. *A Study of U.S. Coast Guard Aviator Training Requirements*, HUMRRO Technical Report 69-102, December 1969.

atmospheric and electronic environment in which it operates. In them can be practiced nearly all of the skills associated with operational missions, from the simplest procedure to the most complex multi-dimensional task. Their design is determined by two primary considerations: the state of the simulation engineering art, and the requirements of the missions for which training is intended. In some cases, training in these high-fidelity devices meets legal requirements for flight training and experience. In fact, it is likely that future SST pilots will fulfill all FAA specified training requirements in such devices, and the first experience at the controls of the aircraft itself will be on a revenue flight.

The present study of Coast Guard training requirements led to the functional design of simulators for the HH52A, the HH3F, the HU16E, and the HC130B. These simulators are described in a Qualitative Materiel Requirement (QMR) which constitutes Appendix A of this report.² The requirement for this general design approach was identified without consideration of the economic impact it might have upon the service. The type of training device described below was responsive to training requirements only. The specific configuration of the synthetic training system, of which each simulator is a part, and the number of cockpits required to provide the required amounts of training, were other parameters which had to be taken into consideration in their design. These parameters relate primarily to administrative, economic, and other factors which are not a function of the training requirements per se.

Other considerations interacted with the design of the equipment described in this report. These are largely a function of engineering parameters, such as formulation of specific engineering design concepts, and are not essential to development of a statement of functional characteristics such as characterizes QMRs. However, it was considered appropriate to resolve a number of design issues during the preparation of the QMR in order to eliminate ambiguity and to assure that the equipment built in response to the QMR would permit the required training to be conducted. This was felt to be a particularly useful step to take where recent experience with the development of somewhat comparable equipment for the U.S. Army had shown uniquely applicable solutions to design problems.

The remainder of the report describes the training equipment found to be appropriate for Coast Guard use, discusses the magnitude of the training for which it is suitable, provides economic data and a cost-benefit basis for a decision by the Coast Guard to undertake its development. Estimates of the cost of acquiring, housing, and operating this equipment are provided. For procurement management purposes, a schedule of significant development and procurement milestones also is provided.

SIMULATOR COCKPIT REQUIREMENTS AND THE VARIABLE COCKPIT TRAINING SYSTEM

SIMULATORS FOR TRANSITION AND QUALIFICATION TRAINING

Development of training syllabi for the flight simulators described in this report was beyond the scope of the present study. However, in order to define certain simulator design parameters, such as the number of each type of cockpit required, the amount of synthetic flight training to be conducted had to be determined. Therefore, the impact of

²A QMR is a statement of a military need for a new item, system, or assemblage, the economics, technical and operational feasibility of which has been determined. It is described in Appendix II, *Format for Submitting Qualitative Materiel Requirements*, Army Regulation 705-5, Research and Development of Materiel, Headquarters, Department of the Army, October, 1964.

the introduction of simulators upon transition and qualification training at the Training Section (TRASEC) of the U.S. Coast Guard Aviation Support and Training Center, Mobile, Alabama, was forecast for the Fiscal Year 1974 time period.

The forecasts were in terms of the number of training hours expected to be required in aircraft and in simulators to conduct the required amounts of training following introduction of the simulators. The forecasts were based upon reviews of present training programs and of the training requirements information developed during this study. They represent estimates of the probable amount of training time that will be required to meet these flight and synthetic flight training requirements. It should be noted, however, that these estimates do not constitute endorsements of present training programs or commitment to an exact amount of training to be included in programs to be developed in the future.

The aircraft and simulator training time estimates used to establish simulator cockpit requirements are presented in Table 1 for all projected transition and qualification training courses. Table 2 presents the total cockpit hours forecast to be required annually to provide this training to the projected number of trainees involved.

Table 1

**FY 1970 and Projected FY 1974 Training Requirements
for Each Coast Guard Aviator Trainee in Transition
and Qualification Courses^a**

Course	Present		Projected	
	Flight Hours		Flight Hours	Simulator Hours
HII52A Transition	31		18-20	14-16
HII52A Qualification	78		58-63	30-35
HII3F Transition	36		18-22	20-24
HU16E Transition	25		18-20	12-15
HU16E Qualification	88		50-55	45-50
HC130B Transition	-		-	28-32

^aFlight hours projected in this and subsequent tables, unless otherwise indicated, are the hours required for student training only. Total mission flight hours required at TRASEC also include test, ferry, and instructor training hours. These requirements average 130 hours per aircraft per year.

Table 2

Total Projected FY 1974 Transition and Qualification Training Hour Requirements With/Without Simulators

Course	Trainee Input	Without Simulators		With Simulators	
		Flight Hours		Flight Hours	Simulator Hours
HII52A Transition	44	1,364		792-880	616-704
HII3F Transition	37	1,332		666-814	720-864
HU16E Transition	16	400		288-320	192-240
HII52A Qualification	10	780		580-630	300-350
HU16E Qualification	15	1,320		750-825	675-750
HC130B Transition	15	-		-	420-480

It should be noted that training requirements for an HC130B transition course were included in the forecasts, although no such course presently is being conducted by the Coast Guard. At the present time, transition training is conducted at Coast Guard Air Stations where operational HC130B aircraft are assigned and is supplemented by simulator and ground school training at El Toro Marine Base or by flight, synthetic, and ground school training at Sewart Air Force Base. Since the El Toro training program appears satisfactory to the Coast Guard, assumptions concerning HC130B transition training at TRASEC were based upon experience with the El Toro program.

The information from Table 2 is summarized by aircraft in Table 3. Taking the midpoint of the range of number of simulator hours required annually for each aircraft, it is estimated that the simulator cockpit hours required to provide all projected synthetic transition and qualification training is as indicated in Table 4.

Table 3

Transition and Qualification Training Hour Requirements for FY 1974 by Aircraft With/Without Simulators

Aircraft	Without Simulators		With Simulators	
	Flight Hours		Flight Hours	Simulator Hours
HH52A	2,144		1,372-1,510	916-1,054
HH3F	1,332		666- 814	720- 864
HU16E	1,720		1,038-1,145	867- 990
HC130B	-		-	420- 480

Table 4

Midpoint Simulator Cockpit Hours Required to Provide Projected Transition and Qualification Training

Aircraft	Midpoint Cockpit Hours
HH52A	985
HH3F	792
HU16E	928
HC130B	450

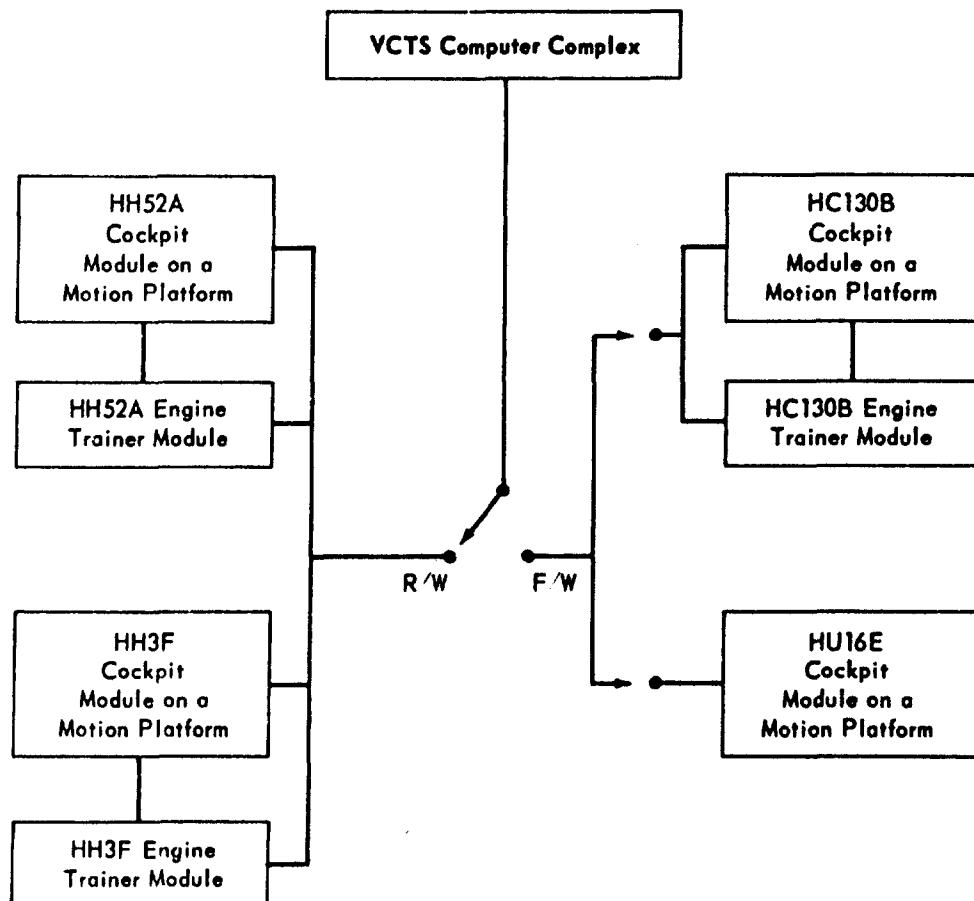
It may be seen from Table 4 that none of the simulator cockpits is required for transition and qualification training on a full-time basis. The largest single requirement is that associated with the HH52A—985 hours, or approximately four hours per day (assuming 48 five-day weeks per year). The use of the relatively expensive computer complex would be inefficient if no greater demand were placed upon it.

A more efficient design would be one which allowed time sharing of the computer complex among a number of cockpits. Such an approach has been implemented elsewhere. Several commercial airlines have simulator systems which consist of two unrelated aircraft simulators which time-share a

single computer. The Navy has a basic instrument trainer system which consists of four identical simulated aircraft and one computer. The Army has under development a helicopter simulator system which consists of four simulators and a single computation system. The Air Force currently is evaluating proposals for the development of a system modeled after that of the Army. A multi-simulator design approach also appears desirable for the Coast Guard.

A Qualitative Materiel Requirement for a system of flight simulators to meet aviator transition and qualification training requirements has been prepared and constitutes Appendix A of this report. The System has been labeled the Variable Cockpit Training

Schematic Representation of the VCTS



NOTE: The representation is of the VCTS operating in its rotary-wing configuration augmented by the addition of HH52A and HH3F engine trainer modules. Repositioning the "switch" to the fixed-wing position would associate the computer complex with the two fixed-wing cockpit modules and associated equipment. A fixed-wing VCTS configuration would result. Alternately, a second computer complex (not shown) could be procured for use with the two fixed-wing modules, and simultaneous training in all four cockpits would be available.

Figure 1

System (VCTS), because it consists of a computer complex with supporting peripheral equipment and computer programs, to which may be added up to two cockpit modules representing various search and rescue aircraft.

Two configurations of the VCTS are required in order to conduct all of the synthetic training identified in this report: a rotary-wing configuration consisting of one HH52A and one HH3F module with their associated motion platforms; and a fixed-wing configuration consisting of one HC130B and one HU16E module with their associated motion platforms. Each configuration will be controlled by a digital computer complex. The two cockpits will time-share the computer, thus providing simultaneous training in each.

Should funding limitations preclude procurement of both the rotary- and the fixed-wing configurations, the design of the VCTS is such that fixed-wing modules can be used in conjunction with the computer portion of the rotary-wing configuration.

Figure 1 is a schematic representation of the VCTS in its rotary-wing configuration. The figure also shows schematically HC130B and HU16E cockpit modules and associated motion platforms which can be used, in place of the rotary-wing modules, by "switching" the computer complex to either or both fixed-wing cockpits. After the various simulator modules and computer programs have been procured, should the latter approach be followed, changing from one VCTS configuration to another in the manner described here will require an average of less than 15 minutes.

Also represented in Figure 1 are engine trainer modules that will be used in conjunction with the three turbine-powered SAR aircraft. These modules, which consist of animated displays illustrating the operation of the respective aircraft engines, will respond to trainee manipulation of the simulator controls, and will be used in the attainment of training objectives associated with aircraft power plant operation. Reference should be made to Appendix A for a more detailed description of the VCTS.

Using the computer-sharing concept described above, the VCTS may be used in its rotary-wing configuration to conduct HH52A and HH3F transition and qualification training simultaneously. The time required for such training is estimated to be 985 hours per year. In an alternate fixed-wing configuration, an additional 928 hours will be required for HU16E and HC130B training. The total VCTS utilization to meet all projected Coast Guard transition and qualification training requirements, when rotary-wing training is conducted alternately with fixed-wing training, is estimated to be $985 + 928 = 1,913$ hours per year.

SIMULATORS FOR PROFICIENCY TRAINING

After graduation from transition and qualification courses, Coast Guard aviators are required to maintain their proficiency through upgrade training and training designed to maintain minimum acceptable levels of skills already attained. At the present time, all such training is conducted at the Air Station level. The Coast Guard allocates 60 hours aircraft time annually per assigned aviator for such training—or 90 hours for dual qualified aviators. Thus, approximately 34,000 flight hours are allocated annually to flight training at the Air Station level.

Part of this allocation is devoted to the checking of aviator proficiency. Two flight checkrides are administered annually: one is an instrument check and the other is a SAR procedures and aircraft standardization check.³ A major portion of the latter is devoted to aircraft operation skill per se. Much of the training designed to prepare aviators to take these checkrides, as well as the checkrides themselves, may be accomplished efficiently in the VCTS.

The Coast Guard may elect to undertake the development of simulator training programs and synthetic versions of instrument and standardization checkrides. The use of such programs and checkrides will contribute to the accomplishment of the required training and will check objectively the skill level maintained by each aviator. The use of the VCTS to accomplish these training and checking objectives will reduce the requirement for such activities in SAR aircraft at the Air Station level. The proficiency training and checking described herein would not, however, eliminate completely the requirement for proficiency training in aircraft. Use of the VCTS in the manner indicated for 10-15

³First Pilots and Aircraft Commanders receive both checkrides. Copilots receive the instrument checkride only. Other checkrides are included in the various training activities conducted by Air Stations, as specified in the *Coast Guard Air Operations Manual*.

hours per single-qualified aviator, 20-30 hours for rotary- and fixed-wing qualified aviators, and 15-22.5 hours for aviators qualified in two aircraft of the same category, could provide training approximately equal to comparable amounts of training presently being conducted at Air Stations.

Table 5 indicates the number of Coast Guard aviators projected to hold the aircraft qualifications indicated during the FY 1974 time period and considered eligible for the proficiency training described here.⁴ Also indicated in Table 5 is the approximate number of VCTS hours that will be required to provide the proficiency training described above. Using the midpoint of this range of simulator hours required annually for each aircraft, the simulator cockpit hours required to provide the projected proficiency training is indicated in Table 6.

The total VCTS cockpit requirement, that is, the number of cockpit hours required to provide all projected synthetic transition, qualification, and proficiency training for the four Coast Guard SAR aircraft, is indicated in Table 7. In order to provide this training,

Table 5
**Aviators Requiring Synthetic Proficiency Training
and VCTS Hours Required
(Projected FY 1974)**

Qualification	No. Field and Staff Aviators ^a	VCTS Cockpit Hours / Aviator	Total VCTS Cockpit Hours
HH52A	167 ^b	10-15	1670-2505
HH3F	78	10-15	780-1170
HU16E	58	10-15	580- 870
HC130B	76	10-15	760-1140
HH52A / HH3F	66	15-22.5	990-1485 ^c
HU16E HH52A	71	20-30	1420-2030 ^d

^aAviators would be excused from the requirement for annual proficiency training in a particular aircraft during the year in which they undergo transition or qualification training in it.

^bIncludes six aviators: HH52A C123 qualified.

^cIncludes 660-990 hours in the HH3F and 330-495 hours in the HH52A.

^dIncludes 710-1015 hours in each cockpit.

Table 6

**Simulator Hours Required
to Provide Projected
Proficiency Training**

Aircraft	Projected Cockpit Hours
HH52A	3,325
HH3F	1,800
HU16E	1,588
HC130B	950

Table 7

**Simulator Hours Required
to Provide Projected
Transition, Qualification,
Proficiency Training**

Aircraft	Projected Cockpit Hours
HH52A	4,310
HH3F	2,592
HU16E	2,516
HC130B	1,400

⁴ Aviators would not require the described proficiency training in an aircraft in which they qualified during the current year. Therefore, such aviators are not included in Table 5.

simultaneous operation of both a rotary- and a fixed-wing VCTS will be required. Thus, the procurement of a separate fixed-wing configuration or the addition of a second VCTS computer complex to be used with separately procured fixed-wing modules while the first computer complex is used with the rotary-wing modulos, will be required for the conduct of the proficiency training described here. Simulator training would be conducted in the VCTS for approximately 18 hours per day, five days per week, 48 weeks per year.

JUSTIFICATION FOR VCTS PROCUREMENT

The primary justification for the procurement of the VCTS by the Coast Guard is that the proposed simulators will facilitate the training of its aviators. The training value of such equipment is widely recognized. For example, after a recent review of technological advances being made in the construction and use of airplane simulators, the Federal Aviation Administration concluded:

"It appears that a combination of simulator/airplane training results in a pilot who is better trained than one trained in the airplane alone. Simulators permit more concentrated training without waste of time and effort and the trainee can be allowed to see and correct his mistakes without any detrimental effects on safety of flight. Therefore, it becomes more and more worthwhile to utilize ground training devices, particularly aircraft simulators, for training purposes."⁵

Additional justification involves economic considerations. It typically costs less to use simulators for aviator training in place of considerably more expensive-to-operate airplanes. Further, the use of simulators can result in the reallocation of aircraft to the extent that the reduced commitment of aircraft to meet training requirements makes them available for other applications. Savings which can be realized as a result of VCTS procurement are discussed in the next section.

COSTS ASSOCIATED WITH FLIGHT TRAINING

Transition and Qualification Training

Reductions in the amount of flight training in aircraft, while at the same time maintaining or even improving overall trainee skill levels, will be possible when appropriate training programs are introduced with the VCTS at TRASEC. The number of flight hours projected to be required to conduct Coast Guard transition and qualification training courses following introduction of the VCTS was indicated in Table 1. Table 2 gave the total number of flight hours required for each course following introduction of the VCTS. The same information was presented by aircraft in Table 3. The number of flight hours projected to be required for the conduct of the five⁶ HH52A, HH3F, and HU16E transition and qualification training courses was determined from the data in Table 3 and was subtracted from the present (i.e., FY 1970) flight-hour requirements for the conduct of the same training. This yielded the number of flight hours projected to be saved annually at TRASEC by the introduction of training in the VCTS. These projections, which total 1,923 flight hours for all five courses, annually, are indicated in Table 8.

⁵ Federal Aviation Administration, Department of Transportation. *Training Programs, Airplane Simulators, and Crewmember and Dispatcher Qualifications; Flight Maneuvers*, Notice of Proposed Rule Making, Federal Register 34, 6112, April 4, 1969.

⁶ There is no qualification course for the HH3F.

Table 8
**Projected Transition and Qualification Flight Hours
 to be Saved Annually at TRASEC
 With Use of VCTS**

Aircraft	Flight Hours Without VCTS	Projected Flight Hours With VCTS	Projected Hours to be Saved
HH52A	2,144	1,441	703
HH3F	1,332	740	592
HU16E	1,720	1,092	628

Table 9 presents the total fuel, maintenance, and personnel costs of flying each of these three aircraft for the number of flight hours indicated in Table 8. It is the figures contained in the right hand column of Table 9, the dollars⁷ saved by not operating the aircraft for training purposes, which are of interest. The total is \$848,198. To the extent that these savings are not offset by the costs associated with the conduct of VCTS training, the total annual cost of HH52A, HH3F, and HU16E transition and qualification training may be reduced through the introduction of synthetic flight training.

In addition to reducing aircraft operating costs which are attributable to training, other tangible benefits of VCTS procurement may be identified. To provide the aircraft flight hours identified in Table 8, certain minimum numbers of aircraft are required.⁸ For

Table 9
**Projected Annual Aircraft Operating Costs
 and Savings in Transition and
 Qualification Training With/Without VCTS**

Aircraft	A/C Operating Costs Without the VCTS ^a	A/C Operating Costs With the VCTS ^a	A/C Operating Costs Saved With the VCTS
HH52A	\$733,248	\$492,822	\$240,426
HH3F	773,892	429,940	343,952
HU16E	722,400	458,640	263,760

^aAircraft operating costs were determined by multiplying fuel, maintenance, and personnel costs (computed on an hourly basis) by the present or projected utilization hours indicated in Table 8. The costs per hour were \$342, \$581, and \$420 for the HH52A, the HH3F, and the HU16E, respectively. The data from which these costs were derived are contained in Appendix B.

⁷Costs cited here and elsewhere in this report refer to current costs.

⁸Effective utilization of aircraft assigned to TRASEC is equal to theoretical maximum utilization less mission overhead (test, ferry, instructor training). For the three aircraft in question, these values are:

Aircraft	Theoretical Utilization	Overhead	Effective Utilization
HH52A	660	130	520
HH3F	700	130	570
HU16E	700	130	570

Table 10

Projected Number of Aircraft Required in Transition and Qualification Training With/Without VCTS and Projected Aircraft Savings With VCTS

Aircraft	Aircraft Required Without VCTS	Aircraft Required With VCTS	Aircraft Saved With VCTS
HH52A	1	3	1
HH3F	3	2	1
HU16E	3	2	1

example, an HH52A is required at CASEC for each scheduled 520 flight training hour, or portion thereof. An HH3F or an HU16E aircraft is required at TRASEC for each scheduled 570 flight training hours or portion thereof. Table 10 presents the number of each of these three aircraft required to provide the flight hours indicated in Table 8. It will be noted that, through the introduction of the VCTS and the consequent reduction in the number of flight hours required to conduct transition and qualification training, one HH52A, one HH3F, and one HU16E no longer will be required at TRASEC. The release of these three aircraft for assignment to other (non-training) missions is a benefit in addition to the cost reductions described above.

There will be no savings in flight-hour training requirements at TRASEC associated

with the introduction of a VCTS HC130B cockpit, since no transition or qualification training for that aircraft currently is being conducted there. The justification for the procurement of HC130B synthetic flight training equipment for Coast Guard-conducted transition training must be based instead upon reduced dependence upon the U.S. Air Force and the U.S. Marine Corps for Coast Guard aviator training.

Proficiency Training

Use of the VCTS for service-wide aviator proficiency training was discussed earlier. The economic effect of such training will be a reduction in annual training costs at the Air Stations, since a significant portion of the training currently being conducted there will no longer be required. The amount of simulator training that would be required to meet annual Air Station proficiency training requirements was indicated in Tables 5 and 6. The consequent reduction possible in the allocated aircraft flight hours at the Air Station level is indicated in Table 11. The computations in Table 11 are based upon a reduction in the allocation for aviators qualified in a single aircraft from 60 to 48 hours per year and a reduction in the allocation for aviators qualified in two aircraft from 45 hours in each to 38 hours in each, or from 90 to 66 total hours per year.

Table 11

Total Projected Annual Training Flight Hours With/Without VCTS and Savings From VCTS Proficiency Training

Qualification	No. Field and Staff Aviators	Flight Hour Allocation Without VCTS	Flight Hour Allocation With VCTS	Flight Hours Saved With VCTS
HH52A	167	10,020	8,016	2,004
HH3F	78	4,680	3,741	936
HU16E	58	3,480	2,784	696
HC130B	76	4,560	3,648	912
HH52A HH3F	66	2,970	2,178	792
HU16E HH52A	71	3,195	2,343	852

The flight hours which may be saved with the VCTS are shown by aircraft in Table 12. The total is 7,836 aircraft hours per year. In the right-hand column of Table 12, the dollar savings associated with not using the aircraft for the indicated flight training are shown. To the extent that these savings are not offset by the costs identified elsewhere in this report associated with the conduct of VCTS training and the transportation and per diem of aviators to TRASEC for VCTS training, the total annual costs of service-wide proficiency training may be reduced through the introduction of synthetic flight training.

Table 13 indicates the number of flight hours allocated annually at each of the 22 SAR Air Stations for the conduct of training for pilots qualified in the assigned aircraft. The flight hour balance (hours available less hours allocated for the training of those aviators), the hours that may be allocated to the VCTS instead of to aircraft to accomplish the same training, and the resulting flight hour balance also are indicated in Table 13. The data reflect projected FY 1971 aircraft and pilot assignment and flight hour allocations. Aircraft and aviator assignment for subsequent years have not yet been established by the Coast Guard; therefore the flight hour balance beyond FY 1971 could not be projected.

Table 12

Projected Annual Flight Hour and Dollar Savings From VCTS Proficiency Training

Aircraft	Flight Hours Saved With VCTS	Cost of Flight Hours Saved ^a
HII52A	3,648	\$1,247,616
HH3F	1,728	1,003,968
HU16E	1,548	650,160
HC130B	912	704,976

^aIncludes fuel, maintenance, and personnel costs for the four aircraft involved. These costs per hour of flight time are \$342, \$581, \$420, and \$773 for the HII52A, HH3F, HU16E, and the HC130B. Data from which these costs were derived are contained in Appendix B.

Table 13

Flight Hour Allocation and Balances for Training With/Without VCTS by SAR Air Stations and Aircraft^a

SAR Air Station	Aircraft Assignment	Qualified Pilots ^b	Without VCTS		With VCTS	
			Flight Hour Allocation	Flight Hour Balance	Hours to be Saved	Resulting Flight Hour Balance
Cape Cod	3 HH3F	25	1125	373	300	673
	3 HII52A	25	1125	269	300	569
Brooklyn	3 HH3F	26	1170	89	312	401
	3 HII52A	26	1170	235	312	547
Cape May	2 HII52A	10	600	260	120	380
Elizabeth City	6 HC130	26	1080	-223	312	89
	3 HU16E	15	750	-0-	180	180
	3 HII52A	15	750	-0-	180	180
Savannah	2 HII52A	10	600	251	120	371
Miami	5 HU16E	28	1470	-378	336	-42
	5 HII52A	26	1260	431	312	743
San Juan	3 HU16E	17	855	69	204	273
	2 HII52A	16	795	129	192	316

(Continued)

Table 13 (Continued)
**Flight Hour Allocation and Balances for Training With/Without VCTS
 by SAR Air Stations and Aircraft^a**

SAR Air Station	Aircraft Assignment	Qualified Pilots ^b	Without VCTS		With VCTS	
			Flight Hour Allocation	Flight Hour Balance	Hours to be Saved	Resulting Flight Hour Balance
St. Petersburg	4 HH3F	22	1320	-521	264	-257
New Orleans	3 HH3F	12	720	116	144	260
Houston	3 HH52A	10	600	243	120	363
Corpus Christi	3 HU16E	12	600	69	144	213
	2 HH52A	12	600	380	144	524
Traverse City	2 HU16E	12	600	-375	144	-231
	2 HH52A	12	600	123	144	267
Detroit	3 HH52A	10	600	52	120	172
Chicago	2 HH52A	10	600	147	120	267
San Diego	4 HH3F	22	1320	17	264	281
Los Angeles	2 HH52A	10	600	18	120	138
San Francisco	2 HC130	11	900	-265	132	-133
	3 HU16E	18	900	-0-	216	216
	4 HH52A	18	900	282	246	498
Astoria	2 HH52A	10	600	331	120	45
Port Angeles	3 HH3F	12	720	138	144	282
Barbers Point	3 HC130	14	840	644	168	817
	2 HH52A	11	660	191	132	323
Annette Island	2 HU16E	12	600	-700	144	-556
	3 HH52A	12	600	137	144	381
Kodiak	3 HC130	16	960	-1195	192	-1003
	2 HH52A	11	660	-28	132	104

^aData taken from U.S. Coast Guard Aviation Issue Paper, September 1967, and the Interim Aviation Implementation Plan, Revision 1, May 1967.

^bPilots qualified in two of the assigned aircraft are indicated separately for each aircraft. Thus, the number of pilots indicated in the Qualified Pilots column exceeds the total number assigned in some cases.

In the case of two of the Air Stations listed in Table 13, the flight hour balance which can result from the use of the VCTS to reduce by 12 hours per aviator the presently allocated flight training time will permit a reduction in the number of assigned aircraft. At Miami, there will be an excess of 743 HH52A hours, or 93 more than the scheduled annual utilization of a single HH52A.⁹ At Barbers Point, the HC130B flight hour balance exceeds scheduled utilization of a single aircraft by 17 hours—a particularly

⁹Effective utilization of aircraft assigned to operational SAR units is equal to theoretical utilization less 1/40th for test and ferry flights. For the purposes of this report, effective utilization of aircraft at those units is considered to be equal to theoretical utilization.

significant factor in the case of the HC130B because there are two other Stations which are expected to have negative HC130B flight hour balances.

At two other Air Stations, Cape Cod and Brooklyn, the flight hour balance on the HH3F and the HH52A combined exceed the scheduled utilization of either an HH3F or an HH52A. It will be possible to reduce the aircraft assignment by one HH3F at each of these Stations by utilizing excess HH52A hours to cover the reduced availability of the HH3F. This is significant because it can permit a change in planned HH3F procurement.

Table 14 indicates the changes in aircraft assignments and flight hour balance discussed above as well as reduced aircraft requirements. In addition, other aircraft savings may be possible. For example, the number of HH52As assigned to Houston could be reduced by one utilizing the excess HH52A hours at nearby Corpus Christi to cover the reduction. Further, at some Air Stations, the projected flight hour allocation is insufficient to provide the desired proficiency training in the aircraft, a situation that would be alleviated to some extent by the utilization of the VCTS to provide synthetic proficiency training. For example, the negative HC130B flight hour balance would be reduced at San Francisco and Kodiak and eliminated completely at Elizabeth City.

SAVINGS ASSOCIATED WITH VCTS TRAINING

Rotary-Wing Training

The acquisition cost of the Rotary-Wing Configuration of the VCTS is estimated to be \$2,226,660.¹⁰ When funds become available, it will be augmented by the addition of

Table 14

Aircraft Reductions and Resulting Flight Hour Balance With VCTS

SAR Coast Guard Air Stations	Without VCTS		With VCTS	
	Aircraft Assigned	Flight Hour Balance	Aircraft Assigned	Flight Hour Balance
Cape Cod	3 HH3F	373	2 HH3F	-
	3 HH52A	269	3 HH52A	542
Brooklyn	3 HH3F	89	2 HH3F	-
	5 HH52A	235	5 HH52A	248
Miami	5 HU16E	-378	5 HU16E	-42
	5 HH52A	431	4 HH52A	93
Barbers Point	3 HC130B	644	2 HC130B	17
	2 HH52A	191	2 HH52A	323

¹⁰The VCTS acquisition costs cited here and elsewhere in this report are derived from data contained in the two references cited below. These data indicate estimated mean bids likely to be received from simulator manufacturers for various VCTS components. The estimated range of bids, i.e., from high bidder to low bidder, is $\pm 30\%$ of the estimated average bid. For purposes of estimating savings associated with the use of the VCTS, it is assumed the bid to be accepted will be approximately 15% lower than the average bid received. In the case of the VCTS Rotary-Wing Configuration, for example, the estimated mean bid expected is \$2,619,600 and the estimated cost of the accepted bid is: \$2,619,600 less 15%, or \$2,226,660. The two references are: (a) Personal communication from S.H. Cotton of the Simulation Engineering Corporation, 27 October 1969; (b) "Analysis of Simulator Requirements for the U.S. Coast Guard Variable Cockpit Training System (VCTS)," Report J9006-1 to HumRRO, Simulation Engineering Corporation, Fairfax, Virginia, October 1969.

engine systems trainers at an additional cost estimated at \$96,843, for a total acquisition cost of \$2,323,503. A building to house the VCTS Rotary-Wing Configuration will cost approximately \$300,000.¹¹ Thus, the total investment in rotary-wing simulators for the HH52A and the HH3F will be approximately \$2,623,500.

Annual estimated costs associated with operation of the VCTS Rotary-Wing Configuration are summarized in Table 15. Costs are estimated separately for the situations in which the VCTS is used for transition and qualification training only (i.e., to provide only the HH52A and HH3F VCTS training identified in Table 4) and for transition, qualification, and proficiency training (see Table 7). The total estimated costs associated with these two situations are \$106,715 and \$465,510, respectively.

Table 15
Estimated Annual Costs Associated With
HH52A and HH3F Transition, Qualification,
and Proficiency Training in VCTS

Item Description	Transition and Qualification Training	Transition, Qualification, and Proficiency Training
VCTS Training Administrator ^a	1 officer (pilot) \$ 17,375	1 officer (pilot) \$ 17,375
Secretary	1 civilian (GS-5) \$ 7,100	1 civilian (GS-5) \$ 7,100
VCTS Instructors ^b	2 officers (pilots) \$ 34,750	6 officers (pilots) \$104,250
VCTS Maintenance Personnel	1 civilian (GS-12) \$ 14,795	2 civilians (GS-12) \$ 29,590
	1 civilian (GS-9) \$ 10,495	2 civilians (GS-9) \$ 20,990
Utilities and Building Maintenance ^c	\$ 15,700	\$ 18,100
VCTS Spare Parts ^d	\$ 6,500	\$ 25,000
Academic Instructors	-0-	4 civilians (GS-11) \$ 49,980
Officer Billets for Increased TAD	-0-	4 officers (pilots) \$ 69,500

(Continued)

¹¹Estimated building costs, which include site preparation and furnishings, assumes a 6,000 square foot building at \$50 a square foot.

Table 15 (Continued)

**Estimated Annual Costs Associated With
HH52A and HH3F Transition, Qualification,
and Proficiency Training in VCTS**

Item Description	Transition and Qualification Training	Transition, Qualification, and Proficiency Training
Military Support Billet	-0-	1 enlisted \$ 6,425
Support Facilities		
Maintenance	-0-	\$ 11,300
Travel and Per Diem	-0-	\$105,900
Totals	\$106,715	\$465,510

^aPersonnel costs in this and subsequent tables were derived from Commandant Notice 5010, U.S. Coast Guard, Subject: Annual Standard Personnel Costs, dated 2 September 1969.

^bBased on unit cost of \$17,375 for a rotary-wing qualified Coast Guard aviator.

^cBased upon 5% of building construction costs for building utilities and maintenance plus 2¢ per kWh for operation of VCTS.

^dCost of replacement of burned out or failed components. Figures do not include acquisition of inventory of spare parts.

These data are combined in Table 16 with aircraft operating cost data from Tables 9 and 12 in order to determine the annual estimated savings in training costs which can be expected to accrue to the Coast Guard through use of the VCTS in lieu of the inflight training identified earlier. For rotary-wing transition and qualification training only, the annual savings will be approximately \$477,663. If the Rotary-Wing Configuration of the VCTS also is used for proficiency training as described earlier, the estimated annual savings will increase to \$2,370,452. It might well be reasoned that the reduction of two HH52A and three HH3F aircraft (see Tables 10 and 14) from those required to provide rotary-wing training to Coast Guard aviators would more than offset the estimated costs of VCTS acquisition. Apart from this, however, the savings identified in Table 16 can be

**Estimated Annual Savings in Training Costs
Resulting From VCTS**

Type of Training	Reduced Aircraft Costs ^a	VCTS Operation Costs	Annual Savings
HH52A, HH3F Transition and Qualification Training Only	\$ 584,378	\$ 106,715	\$ 477,663
HH52A, HH3F Transition Qualification, and Proficiency Training	\$2,835,962	\$ 465,510	\$2,370,452

^aData from Tables 9 and 12.

used over a period of years to offset the acquisition costs. The estimated annual savings of \$477,663 associated with use of the VCTS for transition and qualification training only would offset the cost of acquiring the Rotary-Wing VCTS Configuration and the building to house it in about 5.5 years.¹² The corresponding time if rotary-wing proficiency training also is provided in the VCTS is about 1.1 years. Clearly, there is an economic advantage associated with the greater utilization of the equipment which proficiency training would require.

Fixed-Wing Training

The design of the VCTS is such that fixed-wing modules can be added to the Rotary-Wing Configuration as funds become available, and estimates of procurement costs for each module may be found in previously cited references.¹³ The procurement plan for the VCTS outlined elsewhere in this report, however, provides for procurement of a Fixed-Wing Configuration, augmented by an HC130B engine trainer module, as soon as funds become available instead of procuring the various fixed-wing components on a piecemeal basis. For the purpose of determining costs associated with VCTS utilization, it has been assumed that the outlined procedure will be followed.

The acquisition cost of the Fixed-Wing Configuration, augmented with an HC130B engine trainer module, is estimated to be \$2,133,431. Expansion of the VCTS building to house the Fixed-Wing Configuration, will cost approximately \$105,000.¹⁴ Thus, the total investment in fixed-wing simulators for the HU16E and the HC130B will be approximately \$2,238,431.

Annual estimated costs associated with operation of the VCTS Fixed-Wing Configuration are summarized in Table 17. As in the case of the Rotary-Wing Configuration, costs are estimated separately for transition and qualification training only, and for transition, qualification, and proficiency training. In deriving these costs, it was assumed that the Rotary-Wing Configuration had already been procured. The total estimated operating costs associated with the two fixed-wing training situations, that is, without and with proficiency training, respectively, are \$94,745 and \$340,965.

These data are combined in Table 18 with aircraft operating cost data from Tables 9 and 12 in order to determine the annual estimated savings in training costs which can be expected to accrue to the Coast Guard through use of the VCTS in lieu of inflight fixed-wing training. For fixed-wing transition and qualification training only, the estimated annual savings will be \$169,015. If the Fixed-Wing Configuration also is used for proficiency training, the estimated annual savings will increase to \$1,277,931.

The savings identified in Table 18 could be used, over a period of years, to offset the acquisition costs of the Fixed-Wing Configuration. However, it would require 13 years to offset those costs if the Fixed-Wing Configuration were used solely for transition and qualification training. On a purely economic basis, such action could not be justified, since that time period exceeds the 10-year expected service life of the equipment. Procurement would have to be based, not on economic considerations, but rather upon the greater expected aviator proficiency and the reduced dependency upon other services for HC130B training. Procurement of the Fixed-Wing Configuration could be justified on an economic basis, however, if it were used for HU16E and HC130B proficiency training as described earlier. The estimated annual savings of \$1,277,931 associated with transition, qualification, and proficiency training would offset the cost of the Fixed-Wing

¹²The service life of the VCTS is expected to exceed 10 years.

¹³See footnote 8, page 11.

¹⁴Estimated cost of adding 3,000 square feet, at \$35 per square foot, to an existing VCTS building.

Configuration and the expansion of the VCTS building to house it in about 1.7 years. As in the case of the Rotary-Wing Configuration, there is a clear economic advantage associated with the greater utilization of the fixed-wing equipment. It should be noted also that VCTS HC130B proficiency training would allow reassignment of an HC130B from Barbers Point, where it no longer would be required for training, to another SAR unit.

Table 17
Estimated Annual Costs Associated With HU16E and
HC130B Transition, Qualification, and
Proficiency Training in VCTS^a

Item Description	Transition and Qualification Training	Transition, Qualification, and Proficiency Training
Administrative Clerk ^b	1 civilian (GS-4) \$ 6,395	1 civilian (GS-4) \$ 6,395
VCTS Instructors ^c	2 officers (pilots) \$ 35,950	4 officers (pilots) \$ 71,900
Flight Engineer Instructor	1 enlisted (flight rated) \$ 7,465	2 enlisted (flight rated) \$ 14,930
Academic Instructor	1 civilian (GS-11) \$ 12,495	4 civilians (GS-11) \$ 49,980
VCTS Maintenance Personnel	2 civilians (GS-9) \$ 20,990	3 civilians (GS-9) \$ 31,485
Officer Billets for Increased TAD	-0-	4 officers (pilots) \$ 71,900
Military Support Billet	-0-	1 enlisted \$ 6,425
Utilities and Building Maintenance ^d	\$ 4,950	\$ 7,100
VCTS Spare Parts ^e	\$ 6,500	\$ 25,000
Travel and Per Diem	-0-	\$ 55,850
Totals	\$ 94,745	\$340,965

^aThe costs cited in this table are based upon an assumption that the Fixed-Wing Configuration will be procured after the Rotary-Wing Configuration.

^bSee Footnote a, Table 15.

^cBased on unit cost of \$17,975 for a fixed-wing qualified Coast Guard aviator.

^dSee Footnote b, Table 15.

^eSee Footnote d, Table 15.

Table 18
Estimated Annual Reduction in Training Costs With VCTS

Type of Training	Reduced Aircraft Costs ^a	VCTS Operation Costs	Annual Savings
HU16E, HC130B Transition and Qualification			
Training Only	\$ 263,760	\$ 94,745	\$ 169,015
HU16E, HC130B Transition, Qualification, and Proficiency Training	\$1,618,896	\$340,965	\$1,277,931

^aData from Tables 9 and 12.

Transition and Qualification Training Only

One of the features of the VCTS is that, through time-sharing of the computer complex, cockpits for the HC130B and/or the HU16E can be added to the Rotary-Wing Configuration, thus allowing simulator training for those aircraft when training is not being conducted in the two rotary-wing cockpits. Such variations of the VCTS are illustrated schematically in Figure 1. The acquisition of an HC130B cockpit, augmented by an HC130B engine trainer module, would cost approximately \$1,324,536. The acquisition of an HU16E cockpit would cost approximately \$1,128,245. The housing requirement for the VCTS addition would be approximately the same as for the previously discussed Fixed-Wing Configuration, or \$105,000. Thus, the total investment required to acquire and install these fixed-wing additions would be \$2,557,781, or approximately \$319,350 more than the corresponding costs of a complete Fixed-Wing Configuration. Since procurement of a VCTS Fixed-Wing Configuration for transition and qualification training only has been shown not to be cost effective, the piecemeal procurement approach described here would appear desirable only if it should become necessary, because of funding considerations, to procure fixed-wing VCTS components over a period of several years.

Because of the relatively low expenses associated with the HC130B transition training provided by other services, procurement of an HC130B addition to the VCTS Rotary-Wing Configuration could not be justified on an economic basis if only transition training in it were anticipated. In the case of the HU16E, however, Table 9 indicates that the addition of an HU16E cockpit to the VCTS could result in a reduction in transition and qualification training costs of \$263,760 per year. Table 19 indicates that the annual costs of operating this equipment would be \$35,020. Thus, the annual savings resulting from the conduct of HU16E transition and qualification training in the VCTS would be approximately \$228,740.

The acquisition of an HU16E addition to the VCTS would cost \$1,128,245. Expansion of an existing VCTS building by 1,500 square feet to house this added equipment would cost approximately \$52,500. Thus, the total investment required to add a synthetic HU16E transition and qualification training capability to the VCTS Rotary-Wing Configuration would be approximately \$1,180,745. The cost of this investment would be offset by the annual savings in HU16E transition and qualification training costs in approximately 5.2 years. This time period corresponds closely to the 5.5 years that would be required to offset the cost of the Rotary-Wing Configuration itself were it also used only for transition and qualification training.

Table 19

**Estimated Annual Costs in Conduct of
HU16E Transition and Qualification
Training in VCTS^a**

Item Description	Estimated Cost
VCTS Instructor ^b	1 officer (pilot) \$17,975
VCTS Maintenance Personnel	1 civilian (GS-9) \$10,495
VCTS Spare Parts ^c	\$ 3,300
Utilities and Building Maintenance ^d	\$ 3,250
Total	\$35,020

^aThe costs cited in this table are based upon an assumption that the HU16E module and associated motion platforms will be procured after the Rotary-Wing Configuration.

^bSee Footnote a, Table 15, and Footnote c, Table 17.

^cSee Footnote d, Table 15.

^dSee Footnote b, Table 15.

Other Training

It is not feasible, in a document of this nature, to determine the cost effectiveness of all possible combinations of training for which the VCTS is adaptable. Each combination would have its advantages and cost benefits. Data are provided in this report and its Appendices and references, however, so that additional combinations might be considered should such be desired at a future time. Three examples of training combinations which might be considered are as follows:

- (1) HH3F and HH52A transition and qualification training plus proficiency training for aviators assigned to the Eastern Area only.
- (2) HH3F, HH52A, and HU16E transition and qualification training plus HH3F proficiency training only.
- (3) HH3F and HH52A transition and qualification training, HC130B transition training, plus HC130B proficiency training only.

VCTS PROCUREMENT PLANS

The following section of this report describes a plan which can be undertaken by the Coast Guard to procure the VCTS. The plan identifies funding requirements by fiscal year and projects the occurrence of procurement milestones during the procurement cycle.

FUNDING REQUIREMENTS

The identification of funding requirements for VCTS procurement is based in part upon guidance provided by the Coast Guard that (a) funds are available during FY 1970

(and can be carried forward to FY 1971, if necessary) for procurement of the Rotary-Wing Configuration; (b) funds for procurement of additional system components will not become available prior to FY 1972; (c) funds required for management functions associated with VCTS procurement and for construction and furnishing of a VCTS building need not be included in the development of VCTS procurement funding plans.

FY 1970—Because of the amount of time required to accomplish necessary tasks associated with device procurement, tasks which cannot be undertaken prior to identification of the training requirements and device functional characteristics, it is unlikely that VCTS procurement funds can be committed prior to the end of FY 1970. Thus, none of the presently available funds is expected to be required for VCTS procurement during FY 1970.

FY 1971—It is anticipated that a contract for procurement of the VCTS Rotary-Wing Configuration can be signed during the first quarter of FY 1971. The estimated cost of that contract is \$2,226,660. No additional funds are projected to be available for procurement purposes during FY 1971.

FY 1972—Programming additional VCTS procurement funds is possible for FY 1972. Therefore, the remainder of the system may be procured at that time. These funds are estimated to total \$2,230,274.

The funds required to procure the VCTS, by fiscal year, are indicated in Table 20.

Table 20
Estimated Fiscal Year VCTS Procurement
Funding Requirements

Fiscal Year	VCTS Item	Funds
1971	Rotary-Wing Configuration	\$2,226,060
1972	HH3F Engine Trainer	55,026
	HH52A Engine Trainer	41,817
	Fixed-Wing Configuration	2,091,614
	HC130B Engine Trainer	41,817
1971-1972	Total	2,230,274
		4,456,334

MAJOR MILESTONES

Table 21 indicates major VCTS procurement milestones and the time period, that is, quarter year, during which they are projected to occur.

Table 21
VCTS Procurement Milestones

Milestone	Projected Date
VCTS QMR Completed	2nd Quarter, FY 1970
Rotary-Wing Configuration (RWC) Specification Completed	3rd Quarter, FY 1970
RWC RFP Issued	4th Quarter, FY 1970
RWC Contract Signed	1st Quarter, FY 1971
Specification for Fixed-Wing Configuration (FWC) Completed	3rd Quarter, FY 1971
Specification for Three-Engine Trainer Modules (ETM) Completed	3rd Quarter, FY 1971
FWC, ETM RFPs Issued	4th Quarter, FY 1971
FWC ETM Contract Awards	1st Quarter, FY 1972
RWC On Site	3rd Quarter, FY 1972
RWC Acceptance	4th Quarter, FY 1972
HH52A, HH3F ETM On Site	2nd Quarter, FY 1973
HH52A, HH3F ETM Acceptance	3rd Quarter, FY 1973
FWC, HC130B ETM On Site	3rd Quarter, FY 1973
FWC, HC130B ETM Acceptance	4th Quarter, FY 1973

APPENDICES

Appendix A
QUALITATIVE MATERIEL REQUIREMENT (QMR) FOR
A VARIABLE COCKPIT TRAINING SYSTEM (VCTS)

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QUALITATIVE MATERIEL REQUIREMENT (QMR)
FOR A VARIABLE COCKPIT TRAINING
SYSTEM (VCTS)

Section I - Statement of Requirement

1. Statement of Requirement. A training requirement exists for a system of aircraft simulators to be used by the Training Section (TRASEC) of the U. S. Coast Guard Aviation Support and Training Center, Mobile, Alabama, to train Coast Guard aviators to operate a variety of Search and Rescue (SAR) aircraft. The System will make available to the Coast Guard modern training equipment which incorporates state-of-the-art advances in training equipment engineering and training technology. It will have the flexibility required for the modification of training programs and synthetic flight training equipment to reflect changes in training technology, in the Coast Guard mission, and in the equipment employed to accomplish that mission. The System will incorporate design concepts that will permit more comprehensive aviator training than is possible using operational equipment, will lead to reduced aviator training costs, will permit standardization of aviator training throughout the service, and will permit acquisition of the System itself in a modular manner, thus spreading the initial costs of this modern training equipment over a greater period of time.

Section II - Operational, Organizational, and Logistics Concepts

2. Operational Concepts

a. Description.

(1) General. The system of aircraft simulators described in this QMR is composed of a variable combination of simulated aircraft cockpit modules consisting of trainee stations with both pilot and copilot positions and instructor stations from which instructors administer training to pilot and copilot trainees; motion platform modules which provide motion cues associated with simulated flight of the cockpit; a digital computer complex which performs all computations associated with the simulation of the specific aircraft involved, the environment in which it operates, and the training programs employed in it; and other modules which will allow more comprehensive training in specific aspects of aviator performance. These system components may be assembled in a variety of configurations to meet various portions of present and future Coast Guard aviator training requirements. These components and the manner in which they operate in the VCTS are described in this QMR.

(2) Rotary-Wing Configuration. The rotary-wing configuration of the VCTS shall consist of one HH52A cockpit module, one HH3F cockpit module, two motion platform modules (one for each cockpit), and a computer complex. In order of development and projected utilization, the rotary-wing configuration is the primary configuration of the VCTS.

(3) Alternate Configurations. The configuration of the VCTS may be modified by the addition of modules, e.g., engine systems training modules, to the rotary-wing configuration; by the substitution of a fixed-wing cockpit module, e.g., C130B, for the primary rotary-wing modules; by the substitution of a module representing the cockpit of future aircraft; or by some combination of such changes. In cases where additional modules would be added, provision has been made for such growth in the required design concept of the computer complex through utilization of system reserve and/or the addition of computation and memory units. In cases of substitution of components, the System will operate on a disconnect-connect basis. In either case, computer program changes will be required. The additional components and the manner in which they will operate in the VCTS are described in this QMR. Configurations which are anticipated at this time are as follows:

(a) HH52A Engine Trainer Augmentation. An HH52A engine trainer module will be added to the primary rotary-wing configuration. This module, which will illustrate in animation the dynamic aspects of engine operation, will respond to trainee station control input, and will be viewed through the front windshield of the HH52A cockpit module.

(b) HH3F Engine Trainer Augmentation. An HH3F engine trainer module will be added to the primary rotary-wing configuration. This module, which will illustrate in animation the dynamic aspects of engine operation, will respond to trainee station control input, and will be viewed through the front windshield of the HH3F cockpit module.

(c) C130B Configuration. A C130B cockpit module and an additional motion module may be added to the rotary-wing configuration and used, in conjunction with an appropriate computer program, when other training is not being conducted. Once this simulated cockpit and motion module have been added, the training being conducted in the VCTS may be changed from HH3F and/or HH52A training or from HU16E training to C130B training in an average time of not more than 15 minutes.

(d) C130B Engine Trainer Augmentation. A C130B engine trainer module will be added to the C130B configuration. This module, which will illustrate in animation the dynamic aspects of engine operation, will respond to trainee station control input, and will be viewed through the front windshield of the C130B cockpit module.

(e) HU16E Configuration. An HU16E cockpit module and an additional motion module may be added to the rotary-wing configuration and used, in conjunction with an appropriate computer program, when other training is not being conducted. Once this simulated cockpit and motion module have been added, the training being conducted in the VCTS may be changed from HH3F and/or HH52A training or from

C130B training to HU16E training in an average time of not more than 15 minutes.

(f) Fixed-Wing Configuration. The fixed-wing configuration of the VCTS shall consist of one HU16E cockpit module, one C130B cockpit module, two motion platform modules (one for each cockpit), and a computer complex. The fixed-wing configuration may be procured as a unit or may be assembled from the components described in paragraphs (3)(c) and (e) above, and a separately procured computer complex.

(g) Additional Alternate Configurations. Other VCTS configurations may be obtained in response to future training requirements by the development of additional cockpit modules not described in the QMR to replace obsolete modules, e.g., a medium range recovery vehicle cockpit module with appropriate trainee and instructor stations could replace the proposed HU16E cockpit module and its trainee and instructor stations; or an additional type of module could be added, e.g., an extra-cockpit visual display module for any or all cockpit modules.

b. Purpose. The VCTS will be used for the purposes indicated below. In fulfilling these purposes, each simulated cockpit and the training being conducted in it shall operate independently of all other cockpits and training in the System except as specified elsewhere in this QMR. Automatic proficiency measuring and training techniques will be used as indicated below. Pilot and copilot training will be conducted simultaneously. When in a multi-cockpit configuration, all VCTS cockpits shall operate independently.

(1) Transition and Qualification Training. The VCTS will be used at TRASEC in transition and qualification training programs. It will provide training for aviators to operate Coast Guard SAR aircraft under visual and instrument flight rules and under various weight and balance conditions. The training to be accomplished in the VCTS will be integrated with flight and academic training. Emphasis will be placed upon the use of the VCTS to provide training in the following areas:

(a) Cockpit familiarization.

(b) Performance of procedural tasks associated with the operation of this aircraft to include pre-starting procedures, normal and abnormal starting procedures and procedures to be followed when emergency situations arise. Such emergencies include engine failure, engine malfunction during start-up (e.g., hot start), transmission failure, tail rotor failures, hydraulic system failure, ASE or AFCS malfunctions, fuel control malfunctions, boost pump failure, radio failure, loss of fuel and oil pressure, and various electrical system failures.

(c) Performance of normal and emergency flight maneuvers. Operations for which effective training cannot be provided in the

aircraft itself due to safety considerations, such as response to engine fire on take-off, will be trained for and practiced in the VCTS, except that terminal failure emergency conditions such as drive system failures, will not be included.

(d) Instrument Training. The VCTS will be used at TRASEC in transition and qualification training programs to provide instrument flight training in the following areas:

1 Basic Instruments: Clearance; instrument take-off; straight climb and descent; level flight, standard rate climbing, descending and level turns; steep, timed, gyro, and compass turns; acceleration and deceleration in straight and level flight; and recovery from unusual attitudes.

2 Instrument Navigation and Approaches: LORAN, Doppler, ADF, VOR, ILS, GCA, Beep to Hover, TACAN, and associated traffic control procedures.

3 Emergency Conditions: Performance of instrument flight under abnormal engine and flight instrument conditions associated with the emergency conditions described in paragraph 2b(1).

(2) Proficiency Training: The VCTS will be used at TRASEC in the conduct of proficiency training for all Coast Guard aviators who are qualified in the design basis aircraft. Such training shall consist of periods of synthetic flight instruction designed to prepare the aviator for his annual instrument proficiency flight check and will include a synthetic version of that checkride. In addition, proficiency training will include periods of synthetic flight instruction designed to increase aviator proficiency in the aircraft in which he holds qualification. Emphasis in such training shall be upon performance under conditions of aircraft systems malfunction and emergencies. A synthetic checkride designed to evaluate aviator proficiency in the aircraft under such conditions shall be included.

(3) Engine Systems Training: Instruction in normal and emergency use of the engine(s) of each of the turbine powered design basis aircraft shall be provided.

c. Modes of Operation. The VCTS shall operate in three modes: semi-automatic, checkride, and non-training.

(1) Semi-Automatic Mode Operation. When the VCTS is operating in the semi-automatic mode, training will be under the positive control of an instructor pilot who will be located at an instructor station inside the cockpit shell of the simulated design basis aircraft adjacent to the trainee station. He will administer training programs to pilot and copilot trainees (i.e., to aviators occupying the pilot and copilot position of the trainee station) and will simulate the functions of other crewmembers whose role may be required in those training programs, e.g., radio operator in the HU3F or flight

engineer in the C130B. (The flight engineer station in the C130B cockpit may be used for flight engineer training. In such cases, a separate flight engineer instructor shall be employed.) In performing his various instructor functions, the instructor shall utilize, in accordance with requirements of the training program being administered, the following automatic instructional aids:

(a) Demonstration. The VCTS shall exercise the trainee station instruments and the cockpit motion platform in order to demonstrate an aircraft maneuver or series of maneuvers as it would be flown in an optimum manner. Demonstrations shall be available within the computer complex and may be utilized without undue interruption of the instructor's task. Maneuvers to be demonstrated shall include those typically required to be demonstrated to trainees undergoing qualification training in the design basis aircraft under consideration. Recorded verbal expository commentary shall accompany the demonstration.

(b) Performance Recordings. At all times during training activities, the immediately preceding five minutes of simulated aircraft performance shall be recorded and shall be available to the instructor, selectable in one half-minute increments, for immediate replay to the trainees in the cockpit. The replay shall exercise the simulated trainee station instruments and the cockpit motion platform to recreate the aircraft performance during the period of time being recorded.

(c) Error Determination. For those training problems for which a proper solution may be specified, e.g., altitude control during a beep to a hover maneuver, trainee performance which is inconsistent with such a solution will be detected by the VCTS computer complex. Information relating such error data to other events, e.g., ground track position, will be displayed to the instructor automatically.

(d) Automated Training. When selected by the instructor, training and practice problems shall be presented to the trainee automatically. These problems will include appropriate briefings, problem demonstration, and guided practice for the trainee. These problems shall deal with maneuvers such as ILS approaches, beep to a hover, and control of the aircraft under simulated emergency conditions.

(2) Checkride Mode Operation. When the VCTS is operating in the checkride mode, the automatic performance recording and error determination functions described above shall be employed without instructor intervention, and a pre-programed aircraft standardization or instrument checkride or portion thereof (e.g., an ILS) shall be administered to the trainee. During the checkride, data describing trainee performance shall be recorded for quality control of training analysis purposes.

(3) Non-Training Mode Operation. When training activities are not in progress in the VCTS, the computer complex shall be used for the development of automated training and checkride programs and for the processing of data generated during the periods of checkride mode operation. During this mode, the stored checkride data shall be manipulated by the computer in order to provide summary data comparing trainee performance by appropriate groupings. Program output shall consist of hard copy representation of such performance in a form appropriate for training quality control purposes.

3. Organizational and Logistical Concepts

a. Location. The VCTS will be located at TRASEC where it will be used in aviator transition, qualification, and proficiency training programs.

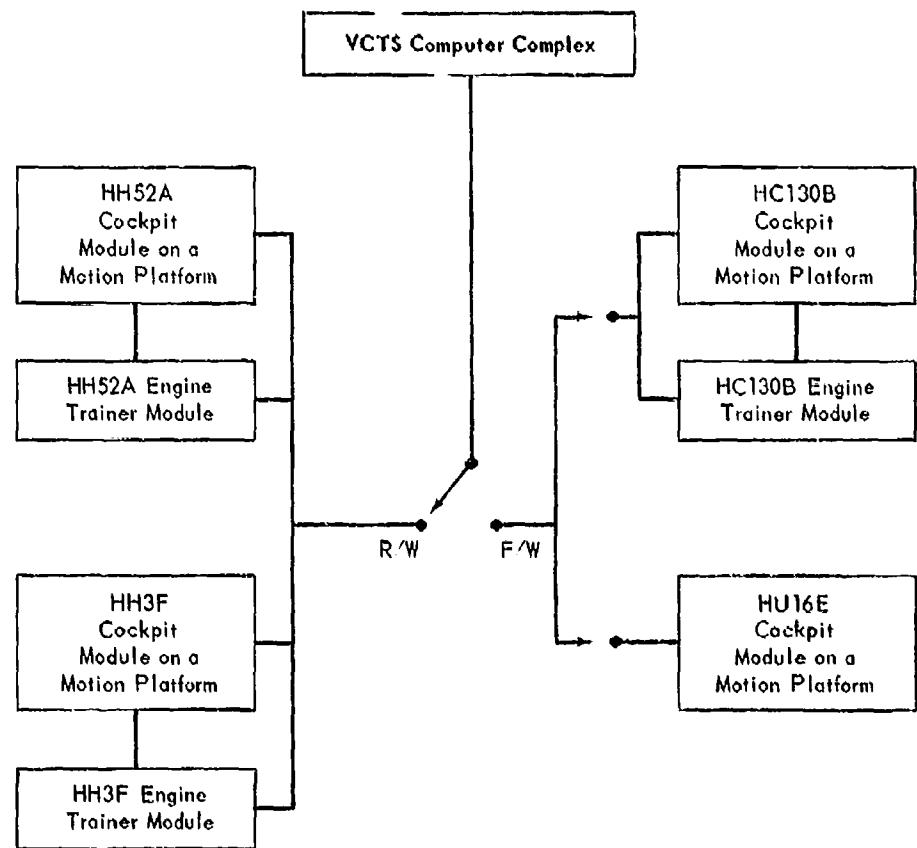
b. Quantity Required. In order to meet the rotary-wing transition and qualification training requirements that are estimated to be valid for the time period FY 1972 through FY 1975, one VCTS, in its rotary-wing configuration (one HH52A cockpit, one HH3F cockpit, two motion platforms, and a computer complex) will be required. Early addition of one HH52A and one HH3F engine trainer module is desired. In order to meet corresponding fixed-wing training requirements, a fixed-wing configuration composed of one C130B cockpit (augmented with a C130B engine trainer module), one HU16E cockpit, two motion platforms, and a computer complex will be required. Should funding considerations dictate, the fixed-wing configuration may be obtained over a period of years by separate procurement of its major components and their use in conjunction with the rotary-wing configuration's computer complex in the manner illustrated schematically in Figure 1.

c. Order of Procurement. The various VCTS components described in this QMR shall be procured in the order indicated below. In the event fund limitations preclude procurement of the fixed-wing configuration as indicated below, a decision will be made concerning the order of procurement of its various components.

- (1) Initial procurement: one rotary-wing configuration VCTS.
- (2) First addition: one HH52A engine trainer module.
- (3) Second addition: one HH3F engine trainer module.
- (4) Third addition: one fixed-wing configuration.
- (5) Fourth addition: one C130B engine trainer module.

d. Manning Requirements: One instructor, proficient in the aircraft being simulated, will be required for each cockpit module in use at any given time. Since the demands made upon a VCTS instructor will be less stringent than those made upon a flight instructor

Schematic Representation of the VCTS



NOTE: The representation is of the VCTS operating in its rotary-wing configuration augmented by the addition of HH52A and HH3F engine trainer modules. Repositioning the "switch" to the fixed-wing position would associate the computer complex with the two fixed-wing cockpit modules and associated equipment. A fixed-wing VCTS configuration would result. Alternately, a second computer complex (not shown) could be procured for use with the two fixed-wing modules, and simultaneous training in all four cockpits would be available.

Figure 1

(due in part to the automated training aids available to him in the VCTS), each instructor shall instruct in the VCTS an average of five hours per training day. Multiple shift operation is anticipated to meet forecast transition, qualification, and proficiency training requirements. The System shall be designed to allow training to be scheduled for up to 20 hours per day, i.e., four training shifts, for extended periods of time.

Section III - Justification, Feasibility, and Priority

4. Reasons for Requirement

a. The primary justification for the procurement by the Coast Guard of the VCTS is that the proposed simulators will facilitate the training of its aviators. After a recent review of technological advances being made in the construction and use of airplane simulators, the Federal Aviation Administration concluded "It appears that a combination of simulator/airplane training results in a pilot who is better trained than one trained in the airplane alone. Simulators permit more concentrated training without waste of time and effort and the trainee can be allowed to see and correct his mistakes without any detrimental effects on safety of flight. Therefore, it becomes more and more worthwhile to utilize ground training devices, particularly aircraft simulators, for training purposes."¹

b. Additional justification involves economic considerations. It typically costs less to use simulators for aviator training in place of considerably more expensive to operate airplanes. Further, the use of simulators can result in the re-allocation of aircraft to the extent that the reduced commitment of aircraft to meet training requirements makes them available for other applications. Savings which can be realized as a result of VCTS procurement are discussed below.

c. A detailed study of the cost effectiveness of the VCTS in Coast Guard aviator training programs is described in the report referenced in paragraph 20a(2) of this QMR. That study cites the following savings that will accrue from the use of rotary- and fixed-wing configurations of the VCTS for transition, qualification, and proficiency training.

(1) Estimated annual reduction in aircraft flight time allocated for training: 9,759 hours.

(2) Estimated annual reduction in aviator training costs: \$3,650,000.

¹Federal Aviation Administration, Dept. of Transportation. *Training Programs, Airplane Simulators, and Crewmember and Dispatcher Qualifications; Flight Maneuvers*. Notice of Proposed Rule Making, Federal Register 34, 6112, April 4, 1969.

(3) Potential reduction in number of aircraft fully committed to training; three HH13Fs, two HH52As, one HU16E, and one C130B.

d. It is estimated that the savings in training costs resulting from the use of the VCTS instead of aircraft for portions of the flight training identified in the referenced report will offset the acquisition cost of the rotary-wing configuration in 1.1 years. The acquisition cost of the fixed-wing configuration will be offset in 1.7 years.

5. Technical Feasibility. Development of the VCTS is technically feasible at this time. Training equipment of a similar nature is being procured by the U. S. Army, the U. S. Air Force, and various commercial airlines.

6. Priority. The equipment described in this QMR will contribute significantly to the effectiveness of aviator performance. It therefore is considered to be of high priority that initial portions of the VCTS, as described in paragraph 3, be procured as soon as possible.

Section IV - Characteristics

7. Performance Characteristics. Performance characteristics stated herein are intended to reflect training requirements and are not necessarily statements of specific engineering design values. Emphasis in interpreting them should be placed upon meeting both current and anticipated rotary-wing, fixed-wing, and compound aircraft training requirements. The VCTS is not intended to be limited in application to the unique characteristics of present Coast Guard SAR aircraft except where specified herein.

a. The VCTS shall include a digital computation system having the following characteristics:

(1) (Essential) The System shall consist of one or more digital computers, operating as one integrated system; associated peripheral equipment; and all software required to comply with the functional and other requirements specified in this QMR. Output data from the computer shall activate and/or control displays and other equipment and provide for implementation of automatic training features as required with a minimum of conversion or transfer devices. One digital computer system shall provide simultaneous computation and control of two trainee station modules, representing the HH52A and the HH3F aircraft, or the HU16E and the C130B aircraft, and the associated instructor station, cockpit motion, and engine trainer modules.

(2) (Essential) The digital computer or computers shall be a general purpose computer of solid state, integrated circuit construction; be commercially available and field proven; and have memory capacity, word size, speed, and input/output capability

compatible with the real-time simulation requirements of the total training situation described in this QMR.

(3) (Essential) The computer systems shall be provided with the following spare capacity without hardware modifications.

(a) The time utilized in the worst case path through the trainer program during an iteration cycle shall not exceed 75 percent of the time available for computation.

(b) Not more than 75 percent of the high speed memory supplied shall be utilized in the simulation. The spare capacity shall be in blocks of continuous locations to facilitate its use.

(c) Not less than 25 percent of both the input and output capacity shall be spare.

(d) If more than one independent processor or a multi-processor configuration is used for the computer complex, the total spare capacity shall conform with a, b, and c above, and each processor shall not utilize more than 90 percent of the time available for computations, 90 percent of its memory, and 90 percent of its input/output channel capacity.

(4) (Essential) The computer system shall be designed to permit expansion of computation capacity as specified below (minimum acceptable expansion values are cited) without significant design changes to existing hardware.

(a) Memory--50 percent of the total high speed memory.

(b) Input/output--50 percent increase in the total input/output channel capacity.

(c) Computation speed--33 percent increase of the system's average computation speed.

(5) (Essential) The computer system shall provide for real-time processing of all operational programs with no decrement stepping, oscillating, or erratic instrument indications or control movements, and shall provide stability of solution of the System's equations. Operational programs shall provide a solution rate sufficiently high to assure simulation of the aerodynamic characteristics of the design basis aircraft.

(6) (Essential) Sufficient auxiliary computer storage capacity shall be provided for the storage of data describing trainee performance from both trainee station modules accumulated during a triple shift training day of operation in the checkride mode.

(7) (Essential) Peripheral input, output, and program preparation equipment, as required, will be provided as part of the computer complex.

(8) (Essential) Provision will be made for the development of automated training programs, demonstrations, and checkride programs, using appropriate VCTS computer components, during non-training mode operation.

(9) (Essential) The following programs will be provided with the computer. They shall be supplied in a form acceptable for insertion into the computer via high speed input equipment.

(a) Main simulation program, including executive routine, and recording, scoring, and instruction programs or sub-routines.

(b) Performance measurement programs.

(c) Verification and acceptance programs.

(d) Maintenance and test programs.

(e) Commercially available software to accompany the computer shall include but not be limited to utility, compiler, assembler, loader, conversion, memory dump, and peripheral control programs.

(f) Training and checkride programs, including malfunction insertion, automated training, demonstration, and quality control data processing programs.

(10) (Essential) The computer shall be programmed to faithfully simulate the design basis aircraft and their on-board systems in order to accomplish the training described in paragraph 2 of this document.

(11) (Essential) Equipment which provides interfaces between the computer complex and other VCTS components shall be standardized and interchangeable at the largest component level practicable.

(12) (Essential) Daily readiness check program shall be provided to enable personnel to determine visually that the VCTS is ready for operation.

(13) (Essential) If more than one independent processor or a multi-processor configuration is used for the computer complex, programs shall be provided to accomplish the following in the event either processor malfunctions:

(a) Operate both cockpit modules and their associated sub-systems in a degraded fashion such that minimum interference with

training shall occur, e.g., so that non-automated training independent of simulated problem world parameters may be conducted.

(b) Operate either cockpit module without degradation of training.

b. The VCTS shall include trainee stations corresponding to the HH52A aircraft, the HH3F aircraft, the C130B aircraft, and the HH16E aircraft. Each trainee station shall have the following characteristics:

(1) (Essential) Each trainee station shall consist of a reproduction of the flight compartment (pilot and copilot positions and, in the case of the C130B, the flight engineer position) of the applicable operational aircraft. All instruments, indicators, gages, controls, lights, circuit breakers, computers, and switches shall be furnished and located in the same position as in the operational aircraft. All components shall have the proper operating limits marked as in the operational aircraft. Items which are not functionally integrated or operative shall be realistic three-dimensional replicas of the operational equipment.

(2) (Essential) Seats, including shoulder harnesses, shall be duplications or facsimiles of those installed in the operational aircraft.

(3) (Essential) Trainer control loading shall correspond to those of the design basis aircraft. Control loading mechanisms shall be located external to the cockpit for maintainability purposes.

(4) (Essential) The control-loading system shall be provided with a fail-safe device that prevents control displacement during either electrical or mechanical system failures. The control-loading system shall be designed to prevent large control displacement upon energizing the system.

(5) (Essential) All electronic communication, navigation, position fixing, and search equipment installed in the design basis aircraft with which the pilot or copilot interacts, except radar, shall be simulated in the trainee station.

(6) (Essential) The trainee area shall incorporate provisions for using the pilots' personal flight gear. All connectors, fittings, physical characteristics, electrical characteristics, and the like, associated with personal flight gear shall correspond to that of the design basis aircraft.

(7) (Essential) An information display panel shall be located in front of the trainee beneath the glare shield in the trainee station. Information presented on this panel shall be visible only when illuminated. The information to be displayed

shall consist of an indication that the trainer is in a freeze condition or that a pre-programmed set of initial conditions has been established and the trainee may assume control.

c. The VCTS shall include instructor stations. A separate instructor station shall be provided in conjunction with each trainee station. Each instructor station shall have the following characteristics:

(1) (Essential) The instructor station shall be designed to permit the necessary instruction and trainer operation functions associated with a particular trainee station, i.e., pilot and copilot positions, to be performed in the most efficient manner by a single instructor. Instructor functions shall be automated to the extent that it is feasible and economical to do so.

(2) (Essential) It shall be possible for the instructor to initiate and conduct training activities or to monitor automated instruction from the instructor station.

(3) (Essential) The instructor station shall be capable of presenting standardized pre-programmed training problems designed for use in developing and maintaining aviator proficiency as described in paragraph 2 of this QMR.

(4) (Essential) Appropriate capabilities shall be provided for the introduction of pre-programmed gradual and abrupt malfunctions and failures. Operation of the controls to introduce or remove a failure or malfunction shall not provide artificial cues to the trainee.

(5) (Essential) Introduction of a malfunction shall produce the appropriate visual, aural, and motion stimuli.

(6) (Essential) The instructor shall have the capability of freezing and unfreezing the training programs or recorded performance play-backs when the simulator is in the semi-automatic mode of operation.

(7) (Essential) It shall be possible to select from pre-programmed initial conditions in order to establish a specific training situation.

(8) (Essential) A voice communication link between each trainee and the instructor shall be provided. A voice recorder and play-back device shall be incorporated and may be used to present pre-recorded instructions.

(9) (Essential) Displays and controls appropriate to the accomplishment of the various instruction and operation functions, e.g., CRT displays and digital readouts, shall be provided.

duplicates of the cockpit instrument may be used provided they are essential to the instruction and operation functions.

(10) (Essential) Plotting devices which display information appropriate for pilot debriefing without further processing shall be provided. These devices shall record ground track, altitude, and airspeed, using scales appropriate for local approaches and cross-country flights within the problem world. The plotting devices shall provide background chart data necessary to effective on-line use by the instructor and for debriefing purposes.

(11) (Essential) The cross-country plots shall cover an area representing approximately 100 nm by 100 nm. Approach plots shall represent smaller areas. Not less than two cross-country areas and eight approach areas within the problem world shall be provided.

(12) (Essential) The plotting devices shall be capable of indicating deviations from pre-programed performance standards.

(13) (Essential) GCA command information which is relayed by the instructor to the trainee when the instructor simulates the function of a ground controller shall be displayed at the instructor station.

(14) (Essential) Information required by the instructor when simulating ground communications stations, e.g., weather reports, shall be displayed at the instructor station.

(15) (Essential) Information describing parameters of the simulation and training problems that are required by an instructor during the conduct of training, e.g., programed wind direction and velocity or programed initial conditions, shall be selectable by him for display at the instructor station.

(16) (Essential) Information identifying the communication equipment and frequencies in use by the trainees shall be displayed at the instructor station.

(17) (Essential) The instructor station shall contain all controls necessary for the instructor to simulate each communication station in the problem world.

(18) (Essential) Controls required to operate the performance and audio recording systems shall be located at the instructor station.

(19) (Essential) A design requirement shall be to minimize the complexity of the instructor station and the number of separate controls located there.

(20) (Essential) The instructor station shall include a digital clock which shall display problem time for those semi-automatic training or checkride problems which do not operate in real time.

d. The VCTS shall include cockpit shells corresponding to each aircraft simulated and shall house the trainee and instructor stations associated with that aircraft. Each cockpit shell shall have the following characteristics:

(1) (Essential) The cockpit shell shall be constructed in a manner to render it as light as feasible consistent with requirements for structural integrity.

(2) (Essential) The inner configuration of that portion of the cockpit shell which houses the trainee station shall duplicate the design basis aircraft with respect to the location of all structural supports and cockpit equipment.

(3) (Essential) The instructor station shall be housed in the cockpit shell to the rear of the trainee station in such fashion that all components of the instructor station shall be out of the normal sight of trainees occupying pilot and copilot positions. That area of the cockpit shell which houses the instructor station need not conform to the physical dimension of the design basis aircraft.

(4) (Essential) The cockpit shell shall include a floor which shall be securely attachable to the cockpit motion equipment described elsewhere in this QMR.

(5) (Essential) Windshields and windows in that portion of the cockpit shell which houses the trainee station shall be constructed of transparent material. All window and door framing members of the simulated aircraft shall be included. Transluscent and opaque overlays with suitable fasteners shall be provided for each window.

(6) (Essential) The cockpit shell shall be constructed in such manner that display components of a visual system may be attached to it at a future time.

(7) (Essential) The cockpit shell shall be ventilated to assure that temperature and humidity at each personnel position remains within ± 1 degrees F. of the temperature five feet above main floor level of the building housing the VCTS.

(8) (Desirable) Methods of ingress and egress shall correspond to those of the design basis aircraft.

e. The VCTS shall include motion platforms, each of which shall be used to provide motion cues to an attached cockpit shell and its associated trainee stations.

(1) (Essential) The motion platform shall be capable of providing motion to the trainee stations that will simulate realistically movement of the simulated design basis aircraft whether that aircraft is the HH52A, the HH3F, the HU16E, the C130B, or other future Coast Guard SAR aircraft.

(2) (Essential) The motion platform shall physically displace the cockpit in the pitch, roll, yaw, heave, and lateral dimensions. Design of the platform shall be such that displacement in the longitudinal dimension may be incorporated at a later date.

(3) (Essential) The simulated motion shall be about pivot points comparable to those of the design basis aircraft, as appropriate.

(4) (Essential) The sensations of motion simulated shall be representative of sensations experienced in the design basis aircraft resulting from changes in attitude and/or flight path. Representative motion cues caused by the following aircraft conditions shall be provided: buffets, stalls, skids, slips, banks, turns, vertical ascent and descent, dives, rolls, acceleration, deceleration, vibrations, and oscillations. These motions shall be based upon six degrees of aircraft freedom computations.

(5) (Essential) The motion system design shall emphasize cues associated with acceleration and deceleration onset. Following initial transient motions, the cockpit motion platform shall return slowly and imperceptibly to normal straight and level flight attitude where appropriate. In such circumstance, however, aircraft instrument indications shall reflect the actual simulated flight condition, regardless of cockpit attitude. All motion associated with normal flight attributable to ambient conditions, e.g., turbulence, shall be included in the motion simulation.

(6) (Essential) The motion system shall allow movement in each dimension independently of movement in other dimensions. The limits of motion shall be adequate to provide appropriate sensations to trainees in the simulated aircraft cockpit.

(7) (Essential) The motion platform shall operate smoothly without hunting and shall not snub against cushion stops during normal operations. There shall be no motion platform oscillation attributable to system instability which could be confused by a trainee with simulated aircraft performance.

(8) (Essential) Cockpit instrument indications shall be synchronized with the cockpit motion. Appropriate operation of the trainee controls shall result in realistic correction of aircraft displacements attributable to simulated turbulence.

(9) (Essential) Leveling and locking devices shall be incorporated into the motion platform that will level and lock the

platform in a positive manner when the system is deactivated due to student or instructor input or system malfunction.

(10) (Desirable) The design of the motion platform shall be such that it is equally suitable to any of the cockpit shells described in the QMR. No hardware changes shall be required to change the motion platform output from any of the design basis aircraft to any other.

f. The VCTS shall include engine trainer modules corresponding to the engines of the HH52A, the HH3F, and the C130B aircraft. Each engine trainer module shall be designed to present engine instrument indications and a partially animated longitudinal cutaway representation of engine dynamics. Each engine trainer module shall have the following characteristics:

(1) (Essential) The module shall be physically located near the trainee station outside the cockpit shell in such position that it may be viewed by the pilot trainee while he manipulates the aircraft controls.

(2) (Essential) The module shall respond, through the VCTS computer complex, to manipulation of the simulated aircraft controls, controls located at the instructor's station, or automated training programs. No additional computational equipment shall be provided as a part of the module except that necessary for interface purposes only.

(3) (Essential) The module shall be capable of displaying instrument values and animated representations of engine dynamics throughout the range of normal operation as well as those associated with possible engine malfunction and ice and salt buildups.

(4) (Essential) All instruments associated with engine functions and the master caution panels of each aircraft shall be represented on the module at a scale easily readable from the trainee station. The instruments shall be arranged to correspond to their relative position in the trainee station.

(5) (Essential) The animated cutaway representation shall include representation of air and fuel flow, pressure buildup, ignition, combustion, and exhaust in the engine and associated systems as appropriate.

g. (Essential) The VCTS shall be designed in such manner that malfunctions of component parts shall result in a minimum loss of system effectiveness.

h. (Essential) The VCTS shall simulate a "problem world" within which each simulated aircraft shall operate. The problem world shall simulate all the atmospheric and electromagnetic effects characteristics of the real world after which it is modeled up to an

altitude of not less than 30,000 feet, or an appropriate lower altitude for the rotary-wing configuration only. These characteristics will affect simulated aircraft, instruments, and motion parameters realistically.

i. (Essential) Not less than 200 separate ground communication and navigation facilities shall be simulated and shall be capable of simultaneous and selective operation. These stations will be located within the problem world or will be accessible to a simulated aircraft operating within the problem world, e.g., a navigation facility used to fix a position.

j. (Essential) Visual and aural stimuli shall be provided in the respective trainee stations and shall correspond to those inside the cockpit of the design basis aircraft under the conditions being simulated.

k. (Essential) In the simulation of emergency conditions, all cues having audible characteristics which are associated with the onset of such conditions shall be correlated in the VCTS with their simulated onset.

l. (Essential) The following weight and balance conditions shall be simulated as appropriate for each design basis aircraft:

(1) Weight as a function of fuel on-board and simulated loading beyond rated maximum gross weight.

(2) Center of gravity positions which are within and exceed recommended aircraft tolerances in each dimension.

m. (Essential) The manufacturer shall provide a library of automated training problems for use with the VCTS. Each problem shall consist of the performance by the trainee of a maneuver or series of maneuvers, such as a VOR approach, and shall present to the trainee the requirement to fly an instrument flight mission or portion thereof.

n. (Essential) The manufacturer shall prepare audio taped briefings to provide necessary instruction and introductions to the automated training, demonstration, and checkride program described in this QMR.

o. (Essential) A program shall be provided which shall consist of an automated simulated flight performance checkride to be administered to instrument rated trainees.

p. (Essential) A library of diagnostic test programs shall be provided which shall consist of short (e.g., an ILS approach) tests of a trainee's ability. These programs shall be used to determine trainee skill levels in the accomplishment of each maneuver involved.

q. (Essential) The manufacturer shall provide a library of automated demonstrations of aircraft maneuvers, e.g., a VOR approach and missed approach. These demonstrations shall include audio accompaniment.

r. (Essential) An automatic quality control of training data processing program shall be provided by the manufacturer. Input data shall be derived from trainee performance during checkride mode operation. Output data shall be in a form appropriate for administrative use to standardize the quality of training being administered.

s. (Essential) The VCTS shall be operated in a controlled environment appropriate for personnel comfort. External environmental control units will not be considered a part of the System.

t. (Essential) During periods of non-use, the VCTS will be stored in its operating location with environmental controls inoperative. System elements which are stored until ready for operational use shall be designed for maximum practical storage life without reconditioning for operational use.

u. (Essential) Mission reliability shall be not less than 92.5 percent for each VCTS module and the computer complex. In defining mission reliability, a mission failure is considered to have occurred after three or more failures which interrupt training, or after more than 15 minutes of downtime for maintenance, during a two and one half-hour mission. Two lost training periods in a fifty training hour week as a result of unscheduled maintenance is the maximum permissible.

v. (Essential) Availability rate (inherent) of a two-cockpit configuration of the VCTS shall be not less than 92 percent. This availability rate assumes an average unscheduled maintenance requirement of five minutes per hour of operation. In a multi-processor configuration, availability rate refers to the entire computer complex.

w. (Essential) Training to be accomplished with the VCTS shall involve problems of up to two and one half ($2\frac{1}{2}$) hours duration.

x. (Essential) Normal utilization of each component of this system shall exceed 200 hours per month. Utilization up to 400 hours per month shall not be precluded.

y. (Essential) The service life of the VCTS shall be not less than 10 years.

z. (Essential) The fidelity of simulation of the design basis aircraft shall be comparable to that required for the certification by the Federal Aviation Administration of commercial airplane simulation under the provision of Appendix B, Part 121, Federal Aviation Regulations.

8. Physical Characteristics.

a. (Essential) The physical characteristics of the VCTS shall be modeled after those specified in MIL-T-23991C, Training Devices, Military; General Specifications For, and other relevant specifications. Manufacturers shall be encouraged to recommend deviation from such specifications where more efficient training can be realized through other design approaches.

b. (Essential) The VCTS shall be designed for installation on a level, concrete floor and shall conform to the following dimensional restrictions:

(1) Floor space requirements: not more than 2400 square feet for the rotary-wing configuration and two engine trainer modules or for the fixed-wing configuration, plus 800 square feet for each additional computer complex or cockpit module with its motion platform and engine trainer module (including space required for access and maintenance purposes).

(2) Height above floor: 20 feet maximum.

(3) Minimum opening to pass through: 12' x 8' (before assembly).

c. (Essential) Modules and components of the VCTS shall be transportable by surface means with minimum disassembly.

d. (Essential) The trainee positions in the cockpit modules shall conform in physical arrangement and dimensions to the corresponding positions in the aircraft being simulated.

e. (Essential) Physical arrangement and dimensions of the instructor stations shall accommodate the 5th through 95th percentile of the military population.¹

f. (Essential) Consideration of health and safety criteria. The proposed System will present health and safety problems similar to those encountered in existing commercial and military synthetic flight training equipment. Similar precautions should apply. Means must be incorporated to preclude entrance to a cockpit module when its motion platform is energized. Inadvertent exposure to sharp edges, moving parts, electric shock and harmful noise levels shall be precluded by special design features.

g. (Essential) Painting and marking of subsystems and components shall conform to accepted Coast Guard practices related to aviation and aviation support equipment.

¹These dimensions are available in Morgan, C. T., Cook, J. S., III, Chapanis, A., and Lund, M. W. (eds). *Human Engineering Guide to Equipment Design*, McGraw-Hill Book Company, New York, 1963.

9. Maintenance Concept and Characteristics.

a. Maintenance Concept. The VCTS shall be maintained by Coast Guard employed maintenance technicians.

b. Maintenance Characteristics.

(1) (Essential) Scheduled maintenance requirements for each computer complex with two cockpit modules shall not exceed one man-hour for each five hours of utilization. It is intended that all scheduled maintenance be accomplished outside of the normal training day.

(2) (Essential) Unscheduled maintenance shall not exceed five man-minutes for each hour of utilization, and shall not result in more than two lost training periods per week. A training period has been lost whenever unscheduled maintenance exceeds 15 minutes or training is interrupted three times during a two and one half-hour training period.

(3) (Essential) All consoles and modules shall be designed to provide for immediate access to major and minor components. Readily available and clearly marked test points shall be provided. Modules, instrument panels and similar components shall be utilized for rapid removal and assembly with rapid action fasteners. Each unit shall, as far as practical, be bench testable by itself without the need of other components of the System. The System and its unitized components shall lend itself to application of rapid automatic diagnostic test equipment.

(4) (Essential) Modules, instrument panels and similar components shall be unitized for rapid removal and assembly. Throw-away components shall be considered when costing up to \$25.

(5) (Essential) The maintenance software package shall include automatic daily readiness tests.

(6) (Essential) Provisions shall be made for automatic module troubleshooting with a failure-location indication system to determine maintenance down a level not greater than three circuit cards. The System shall be designed to minimize the need for special maintenance tools and equipment, the number of personnel, special skills, or prerequisite training requirements for proficient maintenance.

(7) (Essential) The VCTS acceptance tests shall be based on a plan prepared jointly by the developer and user. Equal emphasis shall be placed upon training effectiveness concurrently with the maintenance and reliability evaluation.

(8) (Essential) Use of special order components in the VCTS shall be minimized. U. S. Government stocked parts shall be used where practicable.

10. Human Engineering Considerations.

- a. Appropriate anthropometric data shall be utilized in the design of VCTS modules to enable their convenient and comfortable use by operating and maintenance personnel.
- b. No protective clothing or equipment shall be required.
- c. Sound levels in work areas outside the cockpit shell shall not exceed 80 db. A significantly lower sound level is desired. While sound levels at the trainee station will be a function of the simulation being performed, sound attenuating material may be employed at the instructor station to reduce sound intensity there.
- d. Displays at the instructor station shall be designed to minimize instructor fatigue. Adverse psychological phenomena, such as low CRT flicker rates, shall be avoided.
- e. All VCTS design decisions shall be justified in relation to their positive contribution to the training described in paragraph 2 above.

11. Priority of Characteristics. If, during the development of the VCTS, certain characteristics are unattainable without compromise of other characteristics, the following list of priorities will be considered:

- a. Training value
- b. System flexibility/adaptability
- c. Total life cycle costs
- d. Maintainability/reliability
- e. Automated training capabilities
- f. System reserve/growth capability
- g. Initial cost
- h. Site requirements

Section V - Personnel and Training Considerations

12. Qualitative and Quantitative Personnel Considerations.

- a. VCTS instructors will be Coast Guard aviators or civilian employees who are or have been qualified in the particular aircraft being simulated. While it is not essential that they be currently qualified in that aircraft, they must maintain familiarity with its unique flight characteristics. Requirements for additional training

in the operation of the VCTS for the instructors shall be minimized, VCTS instructors (one per cockpit module per training shift, plus one flight engineer instructor per shift for C130B training) shall be in addition to TRASEC personnel required for other duties.

b. The VCTS shall be maintained by Coast Guard employed personnel. Activities associated with computer reprogramming, such as will occur in connection with the development of new automated training and demonstration material and the adaptation of the System to simulate new aircraft, shall be performed jointly by Coast Guard and contractor technical personnel.

13. Training Considerations.

a. VCTS instructors shall be experienced aviators who will require no special flight training in order to qualify for VCTS instructor positions. Training for them shall be limited to that necessary to perform functions associated with VCTS operation. Such training shall be provided by the device manufacturer to up to ten Coast Guard selected instructor trainees.

b. VCTS maintenance personnel training prerequisites shall be identified by the device manufacturer not later than twelve months prior to scheduled delivery of VCTS subsystems to the training site. The manufacturer shall provide all training to such personnel in numbers sufficient to assure availability of the VCTS throughout a four-training shift schedule.

c. VCTS computer programmer personnel training prerequisites shall be identified by the device manufacturer not later than fifteen months prior to scheduled delivery of the initial VCTS subsystem to the training site. The manufacturer shall provide the training required to enable one such programmer to make anticipated changes in computer programs relevant to VCTS training functions.

Section VI - Associated Considerations

14. Training Devices. Additional training devices are not required.

15. Related Materiel. A building to house the VCTS shall be required at the training site. The manufacturer of the initial VCTS subsystem shall be required to provide relevant data to the building designer and/or contractor.

16. Concealment and Deception. Not required.

17. Probable Interest by the British, Canadian, and Australian Armies or MWD Countries. No direct expression of interest has been made. It is unlikely that joint funding of VCTS development would be possible.

18. Existing or Developmental Items of Other Services, Armies, or Countries. The U. S. Army currently has under development the Synthetic Flight Training System (SFTS), a system of helicopter simulators, and the U. S. Air Force has plans to develop a multi-cockpit rotary-wing flight simulator. Each of these activities has features which parallel features described in this QMR. Information exchanges with the other services have been effected.

19. Communications and Electronic Security. Not required.

20. Additional Comments.

a. This QMR was developed by the Human Resources Research Organization (HumRRO) Division No. 6 (Aviation), Fort Rucker, Alabama, under U. S. Coast Guard Contract DOT-CG-9255-A, dated February 14, 1969. Additional documents developed under that contract and related to this QMR and the use of the equipment described herein are listed below. Personnel involved in the development and utilization of the VCTS should be familiar with those documents.

(1) Hall, Eugene R., Caro, Paul W., Jolley, Oran B., and Brown, Cmdr. Gilbert E., Jr. *A Study of U. S. Coast Guard Aviator Training Requirements*, HumRRO Technical Report 69-102, December 1969.

(2) Caro, Paul W., Hall, Eugene R., and Brown, Cmdr. Gilbert E., Jr. *Design and Procurement Base for Coast Guard Aircraft Simulators*, HumRRO Technical Report 69-103, December 1969.

b. If, during the development of the VCTS, it appears to the developing, procuring, or manufacturing agencies that characteristics specified herein require incorporation of certain impractical features and/or unnecessarily expensive and complicated components or devices, costly manufacturing methods and processes, critical materials, or restrictions which do not enhance the training value of the equipment, such matters shall be brought to the immediate attention of Commandant (OSR-2), U. S. Coast Guard, Washington, D. C. 20591, for consideration and decision before the item in question is incorporated into a prototype design.

Appendix B
DERIVATION OF HOURLY OPERATING COSTS
FOR COAST GUARD AIRCRAFT*

Item	Aircraft Type			
	HC130B	HU16E	HU3F	HHS2A
Fuel and Maintenance				
Fuel	\$ 66,000	\$ 19,000	\$ 32,000	\$ 7,300
Structural Maintenance	264,000	111,000	183,000	97,000
Avionics Maintenance	18,000	16,000	18,000	12,000
Total F&M Costs	\$348,000	\$146,000	\$233,000	\$116,300
Annual Utilization	800 hrs	700 hrs	700 hrs	650 hrs
F&M Cost/Hour	\$435.00	\$208.57	\$332.86	\$178.92
Personnel				
Pilots (number)	4	3	3	2
Cost ^b	\$ 71,900	\$ 53,925	\$ 52,125	\$ 34,750
Aviation Rates (# on flight pay)	18	10	12	7
Cost	\$134,370	\$ 74,650	\$ 89,580	\$ 52,255
Aviation Rates (# net on flight pay)	3	1	2	1
Cost	\$ 19,275	\$ 6,425	\$ 12,850	\$ 6,425
General Service Rates (number)	4	2	3	2
Cost	\$ 25,700	\$ 12,850	\$ 19,275	\$ 12,850
Total Personnel Costs	\$270,520	\$147,850	\$173,830	\$106,280
Annual Utilization	800 hrs	700 hrs	700 hrs	650 hrs
Personnel Cost/Hour	\$388.15	\$211.21	\$248.33	\$163.51
Total Cost/Hour	\$773.15	\$419.78	\$581.19	\$342.43

*Cost data derived from Budgetary Subhead Estimates for Aircraft (CMRD-OSR-2) and from COMDTNOTE 5010, 2 September 1969, for Personnel (Annual Standard Personnel Costs, Encl 1 to COMDTNOTE 5010). Aircraft utilization data taken from U.S. Coast Guard Aviation Issue Paper, 1968.

^bThe unit cost for a fixed-wing qualified Coast Guard aviator is \$17,975; for a rotary-wing aviator the cost is \$17,375.

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13. ABSTRACT <p>An exploration of the potential role of flight training devices in Coast Guard aviation training programs which defines the characteristics of required synthetic training equipment and discusses development of plans for funding and procurement of the equipment. The magnitude of the synthetic flight training requirement and the cost-effectiveness benefits to be realized from use of such equipment are discussed. Characteristics of required synthetic training equipment are put in the form of a Qualitative Materiel Requirement (QMR) for a Variable Cockpit Training System (VCTS). The study finds that substantial aviator training cost savings can be realized as a consequence of VCTS utilization.</p>		

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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Coast Guard Aviation						
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Pilot Transition Training						
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